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AN ANALYSIS OF COSTS OF COMPUTER BASED
TRAINING HARDWARE AND COURSEWARE DEVELOPMENT
FOR THE MODEL TRAINING PROGRAM FOR
RESERVE COMPONENT UNITS

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each based on MTP-RC instructional templates. Costs are reported in four labor categories for each type of lesson. Variations in cost between types are discussed and three variables which can affect cost are identified. *Keywords:*

Army Training; M-1 Tanks; Graduate Vehicles
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AN ANALYSIS OF COSTS OF COMPUTER BASED TRAINING HARDWARE AND SOFTWARE DEVELOPMENT FOR THE MODEL TRAINING PROGRAM FOR RESERVE COMPONENT UNITS

EXECUTIVE SUMMARY

Requirement:

The Model Training Program for the Reserve Component Units (MTP-RC) is a research project conceived by the US Army Research Institute (ARI) and the Training Doctrine Command's Training Technology Agency to develop and validate an effective computer-based instructional response to the training challenges created by the introduction of new equipment into the Army inventory. The purpose of this report is to present a cost analysis of MTP-RC hardware delivery system configurations and to present a cost analysis of MTP-RC courseware development.

Procedure:

Approximately 200 hours of interactive courseware were developed for MTP-RC to train four Military Occupation Specialities (MOSs) who maintain the M1 Abrams tank. A two part cost analysis was performed. Part One contains a cost analysis of different configurations of the delivery system; Part Two contains an analysis and comparison of the cost of producing the courseware. The courseware was authored and will be delivered using the MicroTICCIT computer-based training system produced by the Hazeltine Corporation. Different configurations of the host computer with varying numbers of workstations and disk storage were analyzed. Hardware costs are reported in system cost per student hour. The second part of the report presents an analysis of the cost of producing five different types of lessons, each based on instructional templates. A template is composed of a carefully prescribed instructional strategy, a predetermined set of screen display characteristics, and a structured system for student interactions. Costs are reported in the approximate number of hours required by each of four labor categories to produce lessons based on each of the five lesson templates. Variations in production cost are discussed and three variables affecting development time are identified.

Findings:

Following the analysis of the hardware systems, the authors report that a MicroTICCIT system with the Desktop host computer is the model best suited for the typical RC training site, if MTP-RC courseware is to be

widely fielded in the future. The Desktop models with 142 megabytes of disk storage compare favorably in cost per student hour to models that have less disk capacity. The added disk capacity allows greater training schedule flexibility. Following their analysis of courseware production, the authors report that Troubleshooting Simulation lessons required the most labor to produce, followed by Maintenance Simulations, Name, Locate Function, and Input, Process, Output lessons and Troubleshooting Introductions in descending order. Production time per lesson increases as the complexity of the interaction increases, as the complexity of the content increases, and as the amount of content increases.

Utilization of Findings:

Application of the findings reported in this paper provides guidance for evaluating delivery systems for fielding MTP-RC courseware. The information reported on courseware development costs will assist in estimating the cost of producing courseware of a similar technical nature that uses the same lesson templates.

AN ANALYSIS OF COSTS OF COMPUTER BASED TRAINING HARDWARE AND COURSEWARE
DEVELOPMENT FOR THE MODEL TRAINING PROGRAM FOR RESERVE COMPONENT UNITS

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AN ANALYSIS OF COSTS OF COMPUTER BASED TRAINING HARDWARE AND COURSEWARE DEVELOPMENT FOR THE MODEL TRAINING PROGRAM FOR RESERVE COMPONENT UNITS

OVERVIEW OF THE REPORT

Estimating the cost of designing, producing, and delivering instructional materials is a difficult task, and the use of sophisticated computer based training (CBT) systems increases the difficulty. CBT technology brings new factors into the cost of instructional programs, such as the cost of the computer system for development and delivery of the training and the hours required for the programmers to develop the complex code required. In addition, the tasks of instructional designers, graphic artists, and subject matter experts may be very different in CBT programs than they are in programs in other media, further increasing the difficulty of estimating costs. Analysis of the cost experience of current and past CBT programs can aid the process of estimating the cost of future programs.

This report presents an analysis of the costs of the Model Training Program for Reserve Component units (MTP-RC), a research and development program sponsored by the Army Research Institute (ARI) and the Training and Doctrine Command's Training Technology Agency to evaluate computer based training as a means of delivering troubleshooting and maintenance training. The cost of hardware delivery systems and configurations are analyzed and a recommendation made for a configuration to deliver the MTP-RC training. The courseware development costs are also analyzed to determine the relative costs of different types of labor and different types of lessons. This analysis will be useful to planners of future sophisticated technical training courseware. The term "courseware," as it is used in this report, refers to computer programming that integrates text, graphics, and video in the presentation of interactive instruction to soldiers.

This report is composed of two parts. The first part is a cost analysis of the hardware system used to deliver MTP-RC courseware. This analysis is the basis of recommendations of the most cost-effective hardware configurations for fielding of delivery systems. It includes a discussion of:

- (a) the hardware components that compose the delivery system,
- (b) delivery system costs, including calculation of the system cost per student hour,
- (c) the effect of system configuration on system utilization, and
- (d) the effect of disk storage capacity on training schedules.

The second part of the report contains an analysis of the the labor costs for five different lesson types developed for MTP-RC. About three quarters of the 123 lessons produced for the program are included in these five

types. This report examines the labor expended by the prime contractor for lessons during a period when all personnel were trained and the production process was established. Approximately twenty-five large lessons are included. The remainder of the lessons do not fall neatly into types because they have varied structures and designs. The courseware and production steps used in MTP-RC are described, and variations in the five lesson types by labor categories are discussed. The discussion includes the effect of type of content and complexity of instruction on production costs. Another factor in production costs, the development system itself, is not addressed in this report. All production was done on the same system, providing no basis for comparison of systems. This analysis of the cost experience of the Model Training Program provides useful guidance for estimating the cost of producing courseware of similar technical nature that uses the same lesson templates.

The Model Training Program for Reserve Component Units is developing and evaluating state of the art, computer-based troubleshooting and maintenance instruction. The training was designed specifically for Reserve Component units that lack equipment or experienced instructors for traditional training on new equipment. Approximately 200 hours of computer-based training were developed for this program. The sophisticated design of the courseware combines CBT with state-of-the art interactive videodisc.

The MTP-RC instruction is designed to train and sustain skill level 1 and 2 troubleshooting and maintenance skills for four Military Occupation Specialties (MOSs) related to the M1 Abrams tank. The target audience includes two organizational MOSs (45E and 63E) and two Direct Support/General Support MOSs (45K and 63H) in RC units which have CAPSTONE assignments as M1 support units. Computer-based training and simulation are particularly appropriate for these units, as they typically do not have M1 tanks available for training at their home sites.

The MTP-RC courseware is organized into five courses: four MOS-specific courses and one course of common skills such as safety and test, measurement, and diagnostic equipment. The courses train tasks selected by the US Army Research Institute from the respective MOS critical task lists. Each course comprises approximately one third of a complete skill level course for the MOS. The skills and knowledge required to perform the tasks were identified through a front-end training analysis. Course syllabi were then developed and instructional strategies appropriate to the training objectives were selected prior to production of the courseware.

The courseware development process used new design strategies and state of the art courseware authoring and delivery techniques. The instruction is presented with a standard student interface and lesson designs to reduce the amount of time spent learning how to deal with the training system itself. The courseware presents realistic video and graphic images and requires extensive soldier interactions for gaining knowledge and for practicing skills on troubleshooting and maintenance simulations.

Plans for the one-year trial fielding and evaluation of the MTP-RC courseware and hardware call for installation of systems at three Reserve Component units in the second and third quarters of fiscal year 1986. Each unit has soldiers assigned to MOSs with M1 maintenance responsibilities, as listed below.

Unit	Location	MOSs and Maintenance Level
195th Company	Westminster MD	45K, 63H Direct Support/General Support
2198th Company	Dagsboro DE	45K, 63H Direct Support/General Support
1st Detachment, 252nd Armor	Red Springs, NC	45E, 63E, Organizational and 45K, 63H Direct Support/General Support

Figure 1. MTP-RC trial fielding sites.

The 1st Detachment at Red Springs is primarily an organizational maintenance unit, but it also has some Direct Support/ General Support (DS/GS) personnel assigned to it. This site is the only one of the three to have M1 tanks fielded to date.

Soldiers at each site will receive hands-on and written pretests on M1 skills and knowledge prior to beginning their training on computer system. The soldiers will receive their training during weekend drills and annual training. At the end of the fielding, in third quarter fiscal 1987, soldiers will be posttested on both hands-on and written skills. In addition to evaluating the effectiveness of the CBT program by analyzing soldier performance scores, data will be collected on the suitability of the computer-based training system to the Reserve Component training environment. Some factors to be considered are time required for the system operator, ease of scheduling soldiers, and overall utilization of the system.

PART ONE: HARDWARE COST ANALYSIS

Different configuration of the Hazeltine MicroTICCIT system provide various advantages and varying degrees of cost effectiveness. Several configurations possible for the MTP-RC delivery are analyzed in this section of the report to determine the total system hardware cost and system cost per student hour. A recommendation is made for the most cost effective system. In addition, the components of the system are considered for their effect on courseware delivery. The method for calculating system cost is discussed in some detail to provide a model for such calculations for other programs.

Components of the Delivery System

MTP-RC courseware was designed for delivery on a MicroTICCIT system. MicroTICCIT was selected as the delivery system because it was one of the most sophisticated systems available at the time of the award of the MTP-RC contract in 1983. The Hazeltine Corporation system allows screen presentations of video, graphics, and the combination of both. In addition, the system includes courseware management capabilities required to maintain records of soldiers' performance. Three MicroTICCIT systems are analyzed in this report: the Desktop, the System II, and the System III. The three major components of each system are workstations, a host computer, and a disk storage device. Each system can be configured differently, depending upon the number of workstations and disk storage connected to the system.

The Workstation. The workstation is the equipment that displays the courseware to the student and accepts student input. The workstation is connected by coaxial cables to the host computer, allowing the student to interact with the courseware stored on the disk storage device. The workstation used for MTP-RC delivery is composed of:

- o an IBM PC microcomputer with a graphics overlay board designed by Hazeltine,
- o a Sony videodisc player,
- o a Sony color monitor,
- o a keyboard with a keypad and special function keys,
- o a light pen, and
- o a high-speed communications link to the host computer.

The IBM microcomputer contains the communications interface card and a display controller. The display controller is a circuit board that permits videodisc images, text, and graphics to be displayed singly or in combination on the color monitor. Every MicroTICCIT system must have one workstation equipped as a network controller to manage the flow of information between the workstations and the host computer through a special network controller card. Additional details about Hazeltine MicroTICCIT systems are contained in Appendix A.

The Disk Storage Device. Disk storage is a magnetic medium upon which courseware and student record data are written. Data written to the disk are accessible by the workstations through the central processing unit (CPU) in the host computer. Disk storage capacity is measured in millions of bytes or megabytes (Mbytes). The disk storage capacity of each MicroTICCIT system depends on its configuration. The amount of disk storage capacity determines how much courseware is accessible at one time. In addition to the disks, a tape drive is used for loading or unloading courseware and student record data to the disk. The MTP-RC systems are all equipped with a 15 Mbyte cartridge tape drive for loading and unloading programs.

The Host Computer. Each of the three Hazeltine systems uses a different central processing unit (CPU). The processing capacity determines the number of workstations that the host computer can support. The CPU is the part of the host computer that takes information stored in its raw form from the disk storage device and processes it for display at the workstations. It also takes student responses from the workstations and stores them as student records on the disk.

MicroTICCIT System Configurations

The capacities of each of three MicroTICCIT systems are listed in Table 1. Detailed specifications of each system are contained in Appendix A. Desktop systems can support as many as ten workstations. The other two systems can be used for both delivery and authoring. The System II supports up to forty workstations and System III up to sixty-four workstations. The number of workstations the host computer can support is an important constraint when an institution is considering which MicroTICCIT system to field. The number of workstations affects utilization rates and therefore system cost per student hour. These costs are discussed below.

Table 1

Comparison of Three MicroTICCIT Systems

System	Maximum workstations	Megabytes disk storage	Tape drive
Desktop	10	71 or 142	15.4 Mbyte cartridge tape
System II	40	50 or 100	15.4 Mbyte cartridge tape
System III	64	147 or 295	15.4 Mbyte cartridge tape or 25 Mbyte streaming tape

Another consideration in choice of system is the ability to write or revise courseware on the system. Systems II and III permit authoring at any workstation while the Desktop system does not. This authoring capability is not considered necessary for the MTP-RC field sites. In fact, even if the systems fielded do support authoring, no personnel at the sites will be authorized to make changes in the courseware. Personnel at the sites lack the M1 technical expertise required to change content and the programming expertise required to change the code in the MTP-RC courseware. In addition, the special tape sets developed to deliver the courseware maximize the courseware available on-line by having only the code needed to run the lessons. They do not contain the "source" code required for authoring and

revising the on-line lessons. A limited number of emergency changes could be made by field representative at the sites, but most changes would have to be made in a central locations and shipped to the sites.

Delivery System Costs

Method of Calculating System Cost Per Student Hour. Orlansky and String (1979) recommend that delivery system costs be calculated using the "system cost per student hour method" because it accounts for the life-cycle costing variables of maintenance, amortization, and system use. The cost per student hour method was used for this report because this method accounts for most of the variables of interest in military training,

The steps in calculating system cost per student hour are:

1. Total system hardware costs, including maintenance, over the life of the system.
2. Annual cost per workstation.
3. Annual workstation utilization rate.

Table 2 lists the costs of three different MicroTiccit configurations and the intermediary steps in the calculation of system cost per student hour and hardware costs. The hardware and maintenance prices used in this report are based on Hazeltine's December, 1985, catalog prices and do not include training and support. The columns break down the system costs into main steps in the computation of system cost per student hour. Each step will be described below. Appendix B lists all the formulas for computing system cost per student hour.

Column 4 in Table 2 shows the total system cost over 5 years. It is the initial acquisition price of the central processing unit with a designated amount of storage as shown in column 3, plus the acquisition price of the number of workstations given in column 1, plus maintenance costs. The workstation cost including the required videodisc player and associated equipment is approximately \$10,000. The cost of each system, therefore, depends on the host computer, the amount of disk storage, and the number of workstations. In the next section of the report, typical Reserve Component training situations will be presented to illustrate how the system cost is affected by these variables.

Orlansky and String (1979) compared system cost per student hour using a five year amortization period. The five year maintenance cost of the host computer depends on the specific system. The cost ranges from \$4,100 per year for a Desktop system with 71 Mbytes to \$12,000 per year for a System III system with 294 Mbytes. The workstation maintenance cost over five years is based on \$1,000 per year per workstation and includes maintenance on all workstation components including the videodisc player.

Table 2

Cost per Student Hour of MicroTICCl⁺ Systems

NUMBER OF WORKSTATIONS	HOST COMPUTER MODEL	MEGABYTES DISK STORAGE	(5 YEAR) TOTAL SYSTEM COST	(5 YEARS) SYSTEM COST PER WORKSTATION	ANNUAL SYSTEM COST PER WORKSTATION
3	DESKTOP	71	110,500	36,833	7,367
	DESKTOP	142	131,500	43,833	8,767
	SYSTEM II	50	130,000	43,333	8,667
	SYSTEM II	100	155,000	51,667	10,333
5	DESKTOP	71	140,500	28,100	5,620
	DESKTOP	142	161,500	32,300	6,460
	SYSTEM II	50	160,000	32,000	6,400
	SYSTEM II	100	185,000	37,000	7,400
10	DESKTOP	71	215,500	21,550	4,310
	DESKTOP	142	236,500	23,650	4,730
	SYSTEM II	50	235,000	23,500	4,700
	SYSTEM II	100	260,000	26,000	5,200
	SYSTEM III	147	292,500	29,250	5,850
	SYSTEM III	294	335,000	33,500	6,700

COST PER STUDENT HOUR 1000 HRS/YEAR	COST PER STUDENT HOUR 500 HRS/YEAR	COST PER STUDENT HOUR 367 HRS/YEAR	ST' 2
7.37	14.73	20.07	
8.77	17.53	23.89	
8.67	17.33	23.61	
10.33	20.67	28.16	
5.62	11.24	15.31	
6.46	12.92	17.60	
6.40	12.80	17.44	25
7.40	14.80	20.16	33.6
4.31	8.62	11.74	19.59
4.73	9.46	12.89	21.50
4.70	9.40	12.81	21.36
5.20	10.40	14.17	23.64
5.85	11.70	15.94	26.59
6.70	13.40	18.26	30.45

System cost per student hour is a function of the annual system cost per workstation and the annual workstation utilization rate. Annual workstation utilization rate is computed by dividing the total number of hours per year the workstations are used by the number of workstations. For example, if 100 soldiers each use a workstation 10 hours a year, the workstations are in use 1,000 hours a year. If there are five workstations, then the workstation utilization rate is 200 hours per year. System cost per student hour (Columns 7 through 10) is calculated by dividing the annual system cost per workstation by the annual workstation utilization rate.

Workstation Utilization Rates. System cost per student hour is inversely proportional to workstation utilization rates, to system life span, and to the number of soldiers a workstation can accommodate. When system use is constant (e.g., 1,100 hours per year) and the number of workstations is increased (e.g., from three to five) the annual workstation utilization rate decreases, thus increasing the system cost per student hour.

Figure 2 illustrates the relationship between system cost per student hour and workstation utilization rate for a System II with 100 Mbytes as an example. System cost per student hour was computed for the system configured with 3, 5, and 10 workstations at three different workstation utilization rates. For a given number of workstations, as workstation utilization increases, the cost per student hour decreases. Also, if the workstation utilization rate remains constant as the number of workstations increases, then cost per student hour decreases. The same relationship can be seen in the comparison of various configurations of the Desktop system with 142 megabytes of disk storage (Figure 3).

Analysis of MTP-RC fielding situations with typical RC training schedules and student loads will illustrate the influence that different system configurations have on system cost per student hour. It also will identify factors other than capital expenditure that should be considered when selecting a system configuration.

It is possible to calculate system cost per student hour for any system configuration given the data contained in Table 2, the formulas in Appendix B, and the Hazeltine catalog prices for maintenance in Appendix A. The situations presented, although not exhaustive, are illustrative of typical system configurations. The purpose of these examples is to illustrate the effects on cost of the number of workstations and the amount of disk storage.

Number of Workstations. System cost per student hour increases with the number of workstations if the total hours of system use per year is constant. Consequently, as the number of terminals increases, the system cost per student hour increases. This relationship between system cost per student hour and number of workstations can be illustrated using a situation similar to that of the 1st Detachment in Red Springs, NC.

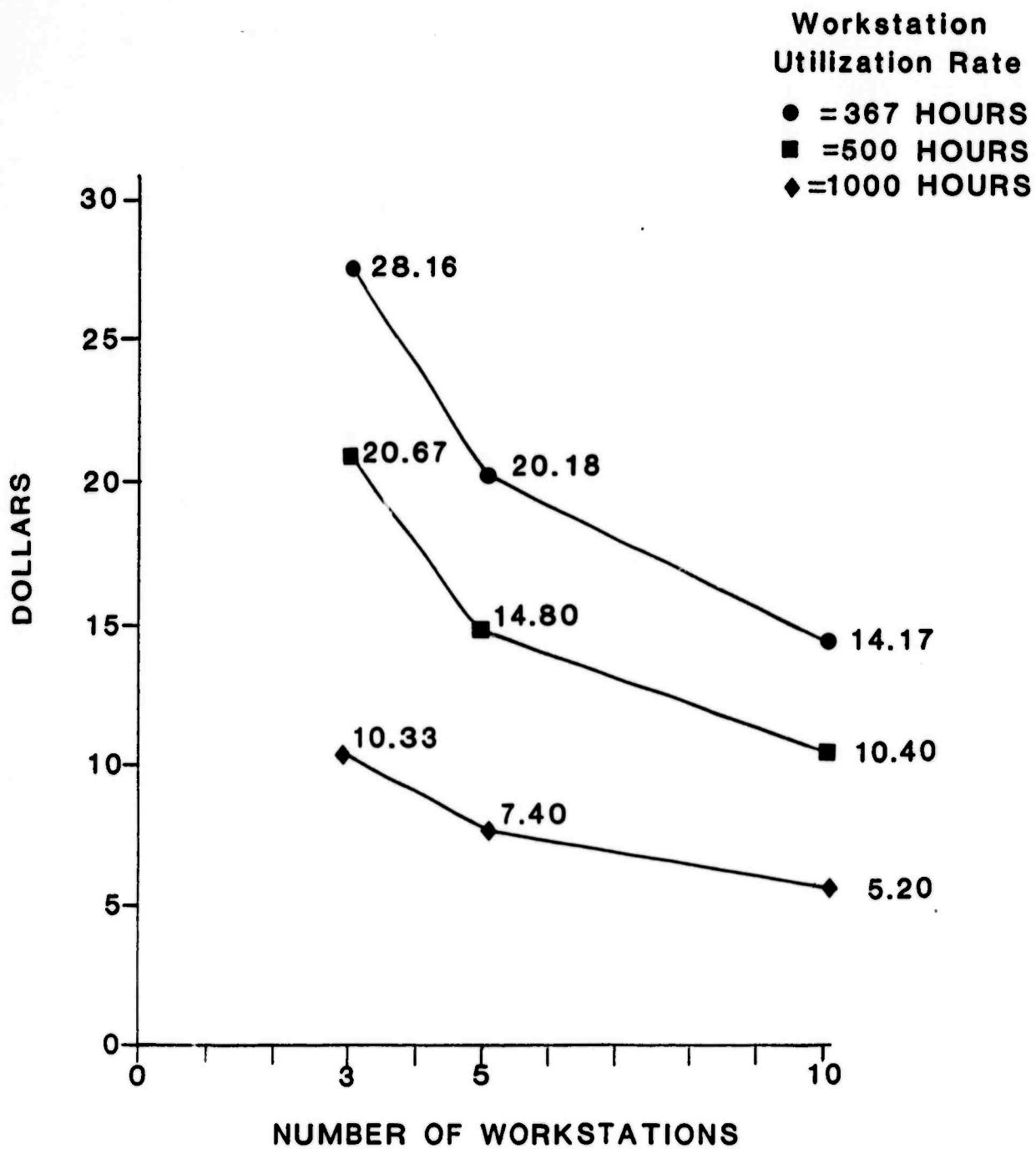


Figure 2. Cost per student hour-100 Megabyte System II.

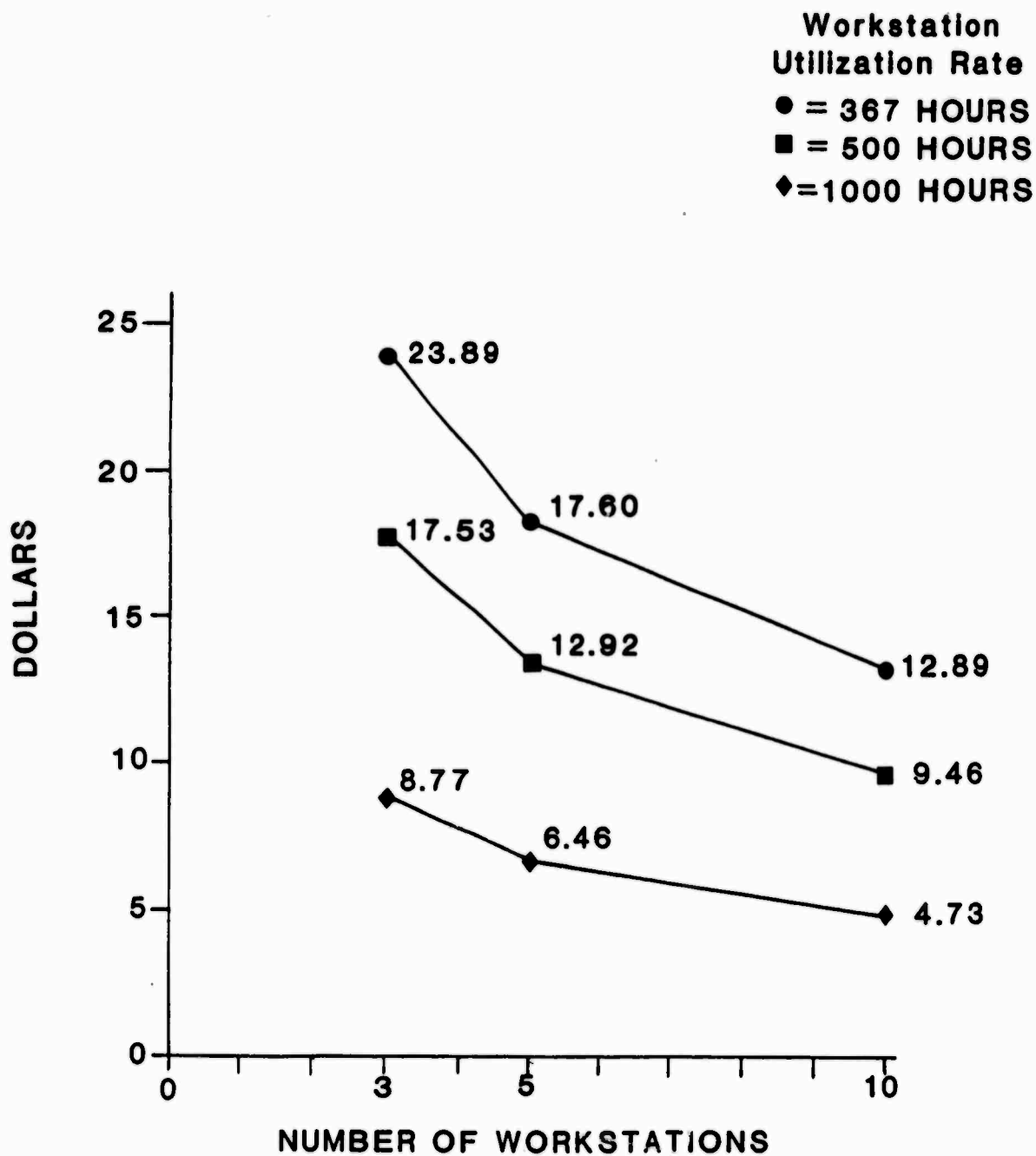


Figure 3. Cost per student hour-142 Megabyte Desktop

In this situation, each of twenty-five soldiers in the unit receives four hours of individual CBT training each month for eleven months. They therefore require a total of 1,100 workstation hours per year in order for each soldier to receive 44 hours MTP-RC training, the approximate number of hours of MTP-RC training for each MOS. If the RC training site has three workstations connected to a System II with 100 megabytes of disk storage, the annual workstation utilization rate would be 367 hours per workstation. Such a system for delivering MTP-RC courseware is scheduled for fielding at the 1st Detachment at Red Springs, North Carolina. If, however, a five workstation configuration were fielded, the annual workstation utilization rate would fall to 220 hours per workstation. As workstation utilization rates fall, system cost per student hour increases. In this case, the system cost per student hour would increase by 19% from \$28.16 per hour to \$33.64 per hour with the addition of two workstations.

Table 3 presents the costs of two configurations of a System II with 100 megabytes disc storage and two configurations of a Desktop with 142 megabytes disk storage. In this table the total workstation hours per year was held constant at 1,100 hours while the number of workstations was increased from three to five. Although adding workstations in this case is not cost effective in terms of hardware costs, there are other factors to consider, such as convenience of scheduling training during the drill period. In fact, sections below will show that it is infeasible to schedule twenty-five soldiers to receive four hours of training per month with only three workstations.

Table 3

Number of Workstations and Cost Per Student Hour

	System II with 100 megabytes disk storage		Desktop with 142 megabytes	
	3 workstations	5 workstations	3 workstations	5 workstations
Total system hardware cost (5 years)	\$155,000	\$185,000	\$131,500	\$151,500
Annual cost per workstation	\$10,330	\$7,400	\$8,767	\$6,460
Annual workstation utilization rate	367 hrs/year	220 hrs/year	367 hrs/year	220 hrs/year
System cost per student hour	\$28.16	\$33.64	\$23.89	\$29.36

Note: Total workstation hours per year = 1,100

Disk Storage Capacity. Disk storage capacity is another factor to consider when selecting a hardware configuration. MTP-RC courseware is recorded on tape sets, each of which includes several units from the syllabus. The system operator at a training site will load the courseware required by a majority of soldiers from the appropriate tape set. Systems with more disk storage allow more of the courseware syllabus to be accessed at one time. This gives greater flexibility for scheduling students based on their rates of individual progress.

Soldiers who proceed through the courseware faster or slower than average soldiers would be unable to access their lessons because the system operator could load only the courseware that was needed by a majority of the students. Training for the faster or slower students would have to be rescheduled and the required courseware reloaded. Having more courseware on line also demands less operator time because the courseware needs to be changed less often.

The advantages of a system with larger storage for a program like MTP-RC with a large amount of courseware are reduced operator time for changing courseware and greater accessibility of courseware. Fewer soldiers would require rescheduling to use the CBT system. The advantage of a system with smaller storage is mainly in reduced cost of the system.

The disk storage requirements of an RC training site depends on the number of MTP-RC courses that must be available at one time. Soldiers training at the DS/GS level should use the courseware targeted for the organizational level to supplement the DS/GS courseware. Therefore, the Westminster and Dagsboro sites with DS/GS soldiers need access to courseware designed for all four MOSSs. These DS/GS training sites would benefit more from delivery systems with greater amounts of disk storage than organizational training sites. The Red Springs detachment is unusual in that it is an organizational maintenance unit with direct support maintenance personnel also assigned to it. Red Springs has the greatest need for courseware storage of all three MTP-RC sites.

The cost figures of two example systems are presented in Table 4, which compares two configurations of the System II and two configurations of the Desktop. In this table, the variable is the amount of disk storage in each system configuration. The number of workstations, total workstation hours per year (1,100), and annual workstation utilization rate (367 hours/year) are constant. The workstation utilization rate is constant because in all cases the total workstation hours per year is divided by three workstations. The system cost per student hour increases 19% from \$23.61 per hour on the 50 megabyte system to \$28.16 per hour on the 100 megabyte system. The system cost per student hour also increases 19% from \$20.07 on the Desktop with 71 megabytes to \$23.89 on the 142 megabyte system. Although the system cost per student hour is higher with the system with greater disk storage capacity, one must balance this cost with the possible benefits derived from decreased operator time and greater scheduling flexibility which would allow training to proceed faster and more efficiently.

Table 4

Disk Storage and System Cost Per Student Hour

	System II with three workstations		Desktop systems with three Workstations	
	50 Mbytes	100 Mbytes	71 Mbytes	142 Mbytes
Total system cost (5 years)	\$130,000	\$155,000	\$110,500	\$131,500
Annual cost per workstation	\$8,667	\$10,333	\$7,367	\$8,767
Annual workstation utilization rate	367 hrs/year	367 hrs/year	367 hrs/year	367 hrs/year
System cost per student hour	\$23.61	\$28.16	\$20.07	\$23.89

Note. Total workstation hours per year = 1,100

The data in Table 4 also show that when the workstation utilization rate is constant (367 hours per workstation) the cost for the Desktop system per student hour is between 9% and 18% lower than for the System II. The Desktop cost is lower even though it has the advantages of larger disk storage capacity. Therefore, if authoring capability is not required and the system to be fielded is only for courseware delivery, the Desktop is the cost effective choice.

Increasing System Utilization and Its Effect on Training Schedules. A third factor that influences system cost per student hour is system utilization. System cost per student hour is inversely proportional to system utilization if the number of workstations is constant. Consequently, cost per student hour can be decreased by increasing system utilization.

The typical RC unit's schedule allows for twenty-two days of computer-based training per year during weekend drills. This schedule gives fairly low utilization of an expensive system. System utilization can be increased by using the same system at two training sites if the training schedule can be coordinated. Another way is to locate the MicroTICCIT system at a regional training center where it can be shared by several RC units. The following paragraphs use a possible MTP-RC fielding plan for Westminster, Maryland, and Dagsboro, Delaware, to illustrate the advantages and disadvantages of sharing a system between two sites. Both units have approximately 25 soldiers eligible for MTP-RC training.

Installation of a System II with 50 megabytes of storage and three workstations is planned for Dagsboro. Each soldier is typically scheduled for one four-hour drill period of individual training per weekend. If each soldier spends four hours per weekend on the CBT courseware, the total system utilization would be 1100 hours. The annual utilization would be 367 hours per workstation, and the cost per student hour would be \$23.61, as shown on Table 5.

Table 5

Two Fielding Scenarios

System II with 50 megabytes disk storage and three workstations			
	2198th	2198th and 195th	
System available	11 mos/yr	6 mos/yr	6 mos/yr
Soldiers Assigned	25	25	21
Drill Periods	11	6	6
Hrs per drill period for individual training	4	8	8
Total CBT hours per soldier	44	48	48
Total workstation hours per year	1,100	2,024	
Annual workstation utilization rate	367 hrs per workstation per year	675 hrs per workstation per year	
System cost per student hour	\$23.61	\$12.84	

It would be impossible for all 25 soldiers to use the system on one weekend, however, if only three workstations were available. Dividing the unit into two groups which drill on different weekends would allow all soldiers four hours of CBT time, but only if some soldiers are excused from group drill activities. This plan would allow all soldiers to receive CBT training in one year at the expense of group activities. In addition, each soldier would have to spend eight hours, half of the monthly drill time, on the CBT system to complete the training in about one year.

Moving the system to Westminster after six months would require that both units be split into four groups each, meeting on four different weekends. In addition, each soldier would have to spend eight hours, half of the monthly drill time, on the CBT each month to complete the training. This plan obviously is infeasible. This plan for sharing systems between sites would increase system utilization and bring the system cost per student hour down 46% from \$23.61 to \$12.84, but it cannot be recommended because of the adverse impact on other activities of the unit. Another disadvantage to this fielding plan is that it subjects sophisticated electronic equipment to the hazards of moving. Some down-time would be required for disassembling, transporting, reassembling, and repairing the system.

Another fielding strategy is the deployment of two small systems, such as a Desktop with four workstations, at each of two training sites. Additional workstations could then be shifted from one RC training site to another as fluctuations in training loads occurred. The advantage of this plan is that only the workstations would be moved, and only on demand rather than on a fixed schedule. The decrease in system cost per student hour would be minimal, however, unless a large number of workstations were moved. The workstations would still face the hazards of moving.

The result of sharing a system between two sites is that system cost per student hour decreases, but doing so places unacceptable restraints on the training schedules of the two RC units. Moving the system to increase system utilization is not a recommended fielding plan because it interferes with unit drills and subjects sophisticated electronic equipment to the hazards of moving.

Although system cost per student hour can be lowered through increased system utilization, attention must be focused on the effect it has on the resulting training schedules. The constraints inherent to RC training schedules means that the system utilization rate at a typical RC unit will be lower than that expected at a site where large numbers of trainees would have daily access to the system.

Summary and Recommendations

The system cost per student hour method of measuring computer-based delivery systems was used in this analysis because it accounts for the life-cycle costs of the system. System cost per student hour was calculated using the following steps:

1. Total system hardware cost over the life of the system.
2. Annual cost per workstation.
3. Annual workstation utilization rate.

The cost of various configurations and training schedules was presented. From the analysis of hypothetical situations, the following points were highlighted.

1. Attempts should be made to increase workstation utilization rates.
2. When the workstation utilization rate has reached the point of negatively affecting the training schedule, then additional workstations should be considered.
3. Consideration should be given to future training needs and how many workstations and how much disk storage capacity may be needed later.

Recommendations.

To field MTP-RC courseware on a wide basis with MicroTICCIT systems, the Desktops offer the lowest cost per student hour of the three MicroTICCIT systems analyzed. When the cost per student hour of a System II and a Desktop with the same number of workstations are compared, the Desktops are lower in system cost per student hour than the System IIs. Even when a Desktop with 142 megabytes is compared to the System II with only 50 megabytes, the Desktop is only a few percent points higher in price. The increased amount of disk storage of the Desktop with 142 Mbytes makes scheduling of training easier and will allow the delivery system to support additional courseware. Although the Desktop does not support authoring of courseware, the delivery sites do not require authoring capability.

System cost per student hour is a useful tool for analyzing CBT delivery systems, but the selection of the right system configuration for a RC training site must balance these hardware costs with scheduling needs and requirements. More information is required to determine the impact of particular system configurations on the training schedules at actual reserve training units. Such information will be collected during the trial field implementation (Phase III) of MTP-RC.

PART TWO: COURSEWARE DEVELOPMENT COSTS

Overview

Labor costs for five courseware templates developed for the Model Training Program for Reserve Component units are presented in this part of the report. Factors that affect courseware development costs are identified. The results should be useful in predicting labor costs when similar courseware development stages and templates are used for the presentation of complex technical content. The following sections are presented:

1. Courseware Templates.
2. Labor Categories in Courseware Development.
4. The Development Process.
4. Findings.
5. Utilization of the Findings.
6. Summary.

Because MTP-RC is a research project designed to determine the efficacy of computer-based training in RC training, it is desirable to know how much it cost to produce different MTP-RC lessons. The costs reported in this document are based on the production records for the program. The cost of developing courseware is influenced by a number of factors. They include:

1. The steps included in the development process.
2. The complexity and quantity of the content.
3. The instructional strategy selected.
4. The courseware authoring language used.
5. The experience of the production personnel.

The discussions of courseware development cost focus on the steps in the development process, but the influence of the other factors are also discussed. The discussion will show how complexity of the content, quantity of the content, and instructional strategy affect the amount of labor and resources required to produce CBT courseware. Because all courseware authoring for this program was done on the ADAPT system in MicroTICCIT, the discussions in the report will reflect only ADAPT authoring. The discussion of the labor hours required for courseware development (Findings) will refer to the experience of the production personnel during peak production; supervisory and support personnel are not included.

Courseware Templates

Understanding the production process requires certain knowledge of the structure of the MTP-RC courseware. MTP-RC courseware is unusual in that most of the lessons were produced using extensive and detailed templates. The templates, which were the result of courseware engineering (Stacy, 1984), were strategies and code for types of lessons. For example, to teach the cognitive objective for understanding the functions of a tank system, a template was developed with interactions to allow soldiers easy access to the information about the system and to test the soldiers' acquisition of the knowledge.

A functional diagram of the system was presented, and by marking a component on the diagram as if pointing to a menu, the soldier received instruction on that component. The next part of that template would be a practice or test session allowing the the soldier to demonstrate mastery of the content.

Although templates are becoming common as a timesaving CBT production tool, the MTP-RC templates are unusual in their scope. Templates on other projects might be simply a reusable screen design format and code for multiple choice questions. An MTP-RC template, on the other hand, would include reusable format and code for introductions, instruction, special assistance, menus, review, and multiple choice tests, all of which are components of an integrated instructional strategy for a type of performance objective. For a more detailed description of the MTP-RC courseware templates and the structure of the courses, refer to Appendix C. The five templates that compose most of the MTP-RC courseware were reviewed for analysis in this report. The five templates are:

1. Name, Locate, Function (NLF).
2. Input, Process, Output (IPO).
3. Troubleshooting Introductions
4. Troubleshooting Simulations.
5. Maintenance Simulations.

The variations in labor required to produce lessons based on each template are discussed in the Findings section of this report.

Labor Categories

MTP-RC courseware was designed and developed by a team with expertise in a variety of areas. The production team included Managers, Instructional Designers, Courseware Developers, Production Supervisor, Subject Matter Experts, Video Specialists, Graphics Specialists, a MicroTICCIT System Operator, and Technical Coordinator. Four labor categories were established to document the courseware production costs in this report.

Time sheets were maintained by all participants on the program to record the hours spent on tasks. The purpose of these records was to allow billing and some tracking of production, but they also provide some useful information for analyzing costs of production. During the last half of the production period, Courseware Developers (CDs) and Graphics Specialists (GSs) also kept detailed production logs, recording the hours spent in production of specific lessons. At least once a day, CDs and GSs recorded the amount of time spent on each lesson that day and the amount of time estimated to complete the work. It was typical for the CDs and GSs to have worked on several lessons each day, often with each lesson in different stages of production, review, or revision.

An example of a Courseware Developer's work log is presented in Appendix D. On this sheet, the CD recorded the time spent on tasks for lessons. The log lists tasks and subtasks in the development process broken down into logical subtasks which allowed the Production Supervisor to track the work flow and estimate the time remaining to complete the lesson. The major tasks are explained in the section below on the development process.

A time sheet for an Instructional Designer is also presented in Appendix D. The time records for IDs and SMEs are not as detailed because they were intended only as time sheets for keeping track of hours spent on the contract. Nonetheless, they allow reasonably accurate estimates of time per segment. IDs were usually working on a small number of segments at one time and had fewer subtasks than the CDs, so it is possible to estimate the amount of hours spent on ID tasks for a lesson by looking at when the lesson scripts were completed and when review were completed and assigning hours from the time sheet to the lessons under development at that time. The time sheets for IDs and SMEs were not designed to keep precise records for lessons, so the estimates developed for these categories must be considered very approximate. They can be considered accurate within 20%.

For other labor categories, detailed logs were not maintained and it was not possible to attribute hours to specific lessons. For example, when Courseware Developers were working on specific single lessons, the Production Supervisor was coordinating the workflow for as many as thirty lessons simultaneously. The Supervisor's hours were then charged to management task categories without assignment to specific lessons. The production cost report is limited to the following labor categories and

tasks for which reasonably accurate records or estimates of time spent per lesson are available:

1. Instructional Designers.
2. Subject Matter Experts.
3. Courseware Developers.
4. Graphics Specialists.

The general responsibilities of these labor categories will be defined briefly before more detailed explanations are given about the roles they played in the development of MTP-RC courseware.

Instructional Designers develop the overall plan for the design of the learning activities. IDs select and analyze content for inclusion in the courseware before designing instruction and the interaction between the soldier and the courseware. In performing these tasks, IDs consult with Subject Matter Experts about content and consult with Courseware Developers about programming code. Once the overall design for a lesson template is completed, IDs write lesson content for specific lessons in that template.

Subject Matter Experts have technical expertise in the content area and usually are familiar with the target audience. SMEs play an important role in the content selection process, in generating content for lessons, and in reviewing content materials for subject matter accuracy.

Courseware Developers have expertise in the authoring language, the authoring system, or the programming language used to translate the ID's content and interaction specifications into courseware code. They generally work from a script or storyboard prepared by an ID for a specific lesson. CDs use the template code for the type of lesson, enter the text from the script, and adjust the code for unusual presentations or interactions demanded by the content of that lesson. MTP-RC CDs were generally responsible for the making and implementing final screen design decisions, such as color of text and location of touch spots on the menus. They also were responsible for the "mechanical" operation of the lesson--making sure that the computer responded appropriately to soldiers' input, encoding scoring criteria, coding menus, and coding video commands. Although the template provided nearly all the code for a "standard" lesson, no lesson was exactly standard. All lessons required some modifications of the code.

Graphics Specialists are experts in visual design who create the technical drawings, charts, menus, diagrams and cartoons used to illustrate the courseware content. GSs generally start with the script and graphics request prepared by the designer of the lesson. They work closely with the ID to understand the instructional intent, with the SME to ensure technical accuracy, and with the CD to make the graphic work properly with the code. Some of the MTP-RC graphics were created with the on-line MicroTiccit graphics editor, but many, especially cartoons, were drawn by hand, transferred into the graphics storage of the computer with a digitizing video camera, and then modified through the graphics editor.

The major production tasks for each of the labor categories are summarized in Table 6. The listed tasks are the activities during the main production phase, that is, after the task analysis and template design are completed.

Table 6

Labor Categories and Major Production Tasks

Category	Main Tasks
Instructional Designer	write scripts, specify video and graphics, review scripts, review lessons
Subject Matter Expert	generate content, review technical accuracy, advise IDs and GSs
Courseware Developer	enter data, modify code, integrate video, review lessons, debug code
Graphics Specialist	design and draw functional graphics and cartoons

The Development Process

One major problem in evaluating or comparing courseware development costs between projects or organizations is that there are neither standardized labor categories nor definitions of the development process itself. Most definitions of the development process include writing the lesson and coding it on-line, but some organizations have both these tasks performed by one person (e.g., a Courseware Author) and some use two people (e.g., an Instructional Designer and a Courseware Developer). Other steps of production may or may not be included by other organizations in their program descriptions. The steps included affect the calculation of the number of hours required to produce a unit of instruction. When comparing courseware production figures, it is essential know which steps were included in the cost figures.

The process used to develop MTP-RC courseware conformed to the Systems Approach to Training (SAT) model with some enhancements. In the early stages, content selection, task analysis, and training task analysis were conducted by the design team. The design process used in MTP-RC differed from the standard SAT process in that a process of generating templates was used. The process called, "courseware engineering," resulted in the development of courseware templates, each of which is a generic, thoroughly structured approach for teaching a specific category of learner behavior. Each template consisted of a carefully prescribed instructional strategy, a

predetermined set of screen display characteristics, and a structured system for student interaction. In this process, an analysis of course content during the development of program objectives led to the identification of the templates required for a given course. The details of the template design process are described by Marco, Begg, Israelite and Bernstein (1985).

Once templates were developed and approved by the design team, lesson production began. Consequently, this cost analysis of the production process does not include template design and coding. The courseware production steps used in the production of MTP-RC and which are the basis of the cost report were:

1. Generate lesson content.
2. ID/SME review.
3. Prepare lesson for production.
4. Input lesson data and adjust code.
5. CL review.
6. ID review.
7. Senior ID review.
8. Army review of lessons.
9. Integrate video and graphics.

Each of these stages of the production process are described below with the relevant activities of each labor category described.

Generate Lesson Content. The IDs wrote the content using the lesson templates and content information provided by the institution and the SMEs. The MTP-RC SMEs were also sometimes used to write lesson content. The lesson content included descriptions of graphic and video images to be used. The descriptions included the image content, any response windows that were required, and any other information to make the graphic easier to produce.

ID/SME Review. Lessons were then submitted to another ID for design review and to a SME for content review. Lessons were returned to the author for revisions. This review process continued until the lessons were approved.

After lesson specifications had undergone their final revision and approval, they were released for on-line production. The production phase consisted of two separate tracks, courseware production and video production. The courseware production phase will be discussed first.

Prepare Lesson for Production. When a lesson was approved, the ID submitted it to the Production Manager. The Production Manager channeled the various components of the lesson specifications to different personnel. Graphics requirements were directed to the GSs for design and input into the system. Components of the lesson that make use of video were turned over to the Video Specialist (VS). The VS took the IDs' video descriptions and developed the storyboards and scripts for video production. The CD reviewed the lesson, gathered any additional necessary information, and prepared the lesson for entry into the system.

Input Lesson Data. It was during this phase of the production process that lesson data were entered into the CBT system by the Courseware Developers. Code templates were used as foundations for all lessons, but typically an individual lesson would require minor modifications to a template. Modifications to a template were made as the lesson data were entered. The Graphics Specialists designed, drew, and edited the various kinds of line drawings, cartoons and other graphics. Graphics were integrated with lesson data during this step in the production process.

CD Review. Each lesson underwent two CD reviews. First, the lesson was reviewed by the CD who entered it. The purpose of the review was to verify that the data entry was accurate and that any modifications to the code template worked as intended. Revisions were made until the lesson was correct. The second CD review was designed as a confirmation that the lesson worked: branches were correct, graphics appeared in the correct place, spelling was correct, etc. Correction and revisions then were made by the authoring CD.

ID Review. When the data entry and review/debug process were complete, a lesson was released for ID review. The ID's main objective was to verify that the on-line lesson accurately reflected the lesson specification, but the ID was also checking to assure that the lesson or graphic as conceived in the specifications was actually effective on screen. This review was essential because the CD sometimes had to rewrite text to fit within the CBT screen format. This review was not intended as a major design review. Major design modifications would have greatly increased development time and generally were avoided by the thorough ID and SME review conducted earlier. Modifications and revisions were usually made by the CD who entered the lesson.

Senior ID Review. The senior ID conducted the final lesson review. This review typically verified that lessons were complete. Occasionally, however, design and production flaws were identified. In such cases, lessons were submitted for revision and modification.

Army Review. When lessons were completed, they were sent to the Ordnance School for review. Because video production was concurrent with early courseware production, some video segments were not available for Army review at this phase of development. Consequently the courseware the Army reviewed at this time sometimes included the graphics but lacked the video. Lesson designs had been previously approved, therefore, changes in the

lesson designs were seldom required as a result of the Army review. The major focus of this review was content accuracy.

At the same time that courseware was being produced, video production was also underway. When lesson content was generated, the author ID wrote video specifications that consisted of detailed descriptions of the video images required for the lesson. These specifications were given to the Video Specialist. It is at this point that the video production process began. It should be noted that not all of the steps required for video production were included in this cost report. The video scripting, storyboarding, shoot, post production work, and cataloging the disc were not included in this report because these tasks relate to the whole of MTP-RC courseware. Consequently, it was not possible to report the amount of time required for individual lessons. It was possible, however, to tabulate the amount of time per template the CDs spent to integrate the video into the courseware.

Integrate Video and Graphics. The video integration process required that the video sequences specified by the ID be inserted into the courseware by a CD. Integrating the video sometimes required adjusting the code, especially if there was motion video or audio. Graphic overlays also had to be integrated into the courseware at this stage of development. Ideally, video would be available when lesson data were first entered into the CBT system. Because of the long lead time required for video production, video integration typically occurred near the end of the development process, prior to final reviews and client acceptance. Once video integration was complete it was possible for the client to review the courseware in its completed form.

Findings: Courseware Production Costs

Cost information figures for the five templates are presented in Table 7. The number of hours required by each of four labor categories is reported for each template. The figures contained in Table 7 reflect the labor involved in the actual courseware production process which could reasonably be assigned to specific lessons. The figures, therefore, neither include the labor performed by the IDs and SMEs in the content selection, task analysis, and training task analysis procedures, nor do the figures include time spent writing evaluations, reports, and general correspondence. The figures also do not include the labor required by the design team to generate the templates or the time required to translate the templates into code. Finally, the figures do not include the time spent by the Video Specialist on the video shoot, video post-production, and disc cataloging.

Table 7

Courseware Production: Average Labor Figures in Hours

LABOR CATEGORY	LESSON TYPE				
	NLF N=6	IPO N=4	INTROS N=5	TROUBLE- SHOOTING N=6	MAINTENANCE N=4
ID	110	110	40	120	155
CD	100	100	60	155	125
GS	50	50	40	80	50
SME	30	30	20	55	75

Note. All figures +/- 20%

The analysis of these records will help for a very rough gauge of relative production costs by lesson type and labor category. The recordkeeping, however, was not intended to provide data for such an analysis, so both the number of lessons for analysis and the accuracy of the data are limited. The figures are most reliable in comparing relative labor per lesson type or labor category. A more carefully controlled study designed to accurately record the hours for a number of segments would be necessary to determine the hours per segments more precisely. Such a study is planned for Phase III of MTP-RC. Nonetheless, a review of the MTP-RC production experience to date provides useful insight into the production process.

The number of lessons for which usable records were available is limited for other reasons in addition to the lack of intent to analyze the production. Many of the Name, Location and Function; Input, Process, Output; and Troubleshooting Introduction lessons were produced with the templates by Hazeltine Corporation under subcontract to Scientific Systems. Hazeltine was not asked to keep production logs by lesson. All of these lessons, about thirty, are therefore excluded from the data base. Other lessons have been excluded because they were not produced during periods of routine production. During the first months of the program, SSI Courseware Developers were learning the ADAPT language, so training time confounds production time. The first few lessons of each type were affected so much by revisions being made to the templates as they went into production that they are not included in the report of routine production. Other lessons simply had missing or obviously inaccurate information; these were not used. Lessons which required extensive modifications to the template too anomalous for inclusion. Even with the exclusion of these lessons, the estimates for

lessons may vary +/- 20% from the average. The approximate number of lessons of each type used in the cost breakdown is included in Table 7.

The figures represent the hours spent by each labor category on each template during the courseware production phase of MTP-RC. The figures represent the amount of time to write and to revise lessons, scripts and generate content. The figures include the amount of time entering code, processing code, debugging, revising code and integrating video and making changes based on Army reviews and information obtained from formative evaluations.

The figures in Table 6 represent approximate averages. Actual production times may vary by 20%. The variation is attributable to a number of variables, including the difficulty of the content, the length of the procedure being taught, and the actual number of items that composed the segment. For example, some Troubleshooting lessons are composed of as few as 200 items while others were composed of as many as 450 items. Some tank systems include five components requiring instruction; others include 10 or 12, so their lessons are longer and require more production time.

The averages for the NLF and IPO lessons include some lessons produced before all the production staff were working at the productivity rates they achieved on subsequent templates. The NLFs and IPOs were the first kinds of segments to be produced. Therefore, IDs were beginning to learn about the content, CDs were still increasing their knowledge of the authoring language, and GSs had not yet developed all of the labor saving techniques they eventually created. The data listed for the other three templates are based on average times when personnel were working at higher productivity rates.

NLF and IPO Lessons. Although the hours required for the NLFs and IPOs are the same, the nature of the work performed by IDs differed between the two templates. NLF lesson content was broader than IPO lesson content. A typical NLF lesson might discuss seven M1 tank system parts while a typical IPO lesson might discuss three or four of those parts in depth. IPO lessons extended the explanations given in the NLF lesson for parts that required further explanation. So, although the number of parts the ID had to learn about were fewer in number, the ID had to spend more time reading the reference materials and consulting the SME in order to be able to explain the parts in depth. Therefore, the amount of time the ID spent on both types of templates averaged out to the same number of hours.

The time required by the CDs for entering data, debugging, and processing items for both templates was quite similar. Although the CDs had fewer items to encode for IPO segments, the coding was more complex than for NLF segments because of the required changes in screen displays. The amount of time required by the GSs and SME was the same for both templates. The SME consulted with the IDs and explained the operation of the systems. The SME worked with the IDs to identify the majors parts of the system, explain their functions, and generate functional descriptions of system which the IDs used. The SME also was responsible for locating and obtaining existing

visuals of the system parts and was responsible for describing those parts which would require video images. Once the ID had written the segment specifications, the SME reviewed them for technical accuracy.

The SME worked with the GSs to identify what was required of the graphics, which functioned both as menus and instructional content in NLF and IPO segments. There are two types of such graphics: realistic representations of a system (e.g. the engine or transmission) or diagrams of the functional relationships of parts not in close proximity to each other on the tank (e.g. the Laser Range Finder and the Line of Sight Electronics Unit). The SME identified to the GSs the major parts that had to be included in the graphics. The GSs created the graphics based on the guidance of the SME and the ID's segment specifications. The GSs also created many motivational cartoons for the NLF and IPO segments. When video images were not available, the GSs created realistic line drawings of the parts.

Troubleshooting Introduction Lessons. Troubleshooting Introductions required fewer personnel hours to produce than any of the other templates, because they have fewer pages and simpler branching options. The IDs were able to use information that already had been generated for NLFs, IPOs and the "conceptual help" material designed for use within the Troubleshooting Simulation lessons. Typically, the ID worked concurrently on writing the conceptual help material for the Troubleshooting Simulation and on writing the Troubleshooting Introduction.

Compared to NLF and IPO lessons, CDs required fewer hours to enter the data items because there was less material to enter. What material had to be entered required simple branching and contained no tests. GSs also required fewer hours to produce the graphics needed for Troubleshooting Introductions because the GSs were able to modify graphics that had been developed for previous templates, including the graphics required for conceptual help in the Troubleshooting Simulation lessons.

The SME's role in producing Troubleshooting Introductions was different than the role he performed in the production of NLF and IPO lessons. The SME had to identify the feasible set of faults that might be responsible for the symptom that was the focus of the lesson. The SME had to generate the explanations of what each troubleshooting test did. This information was not contained in the soldiers' TM, therefore, the SME had to establish the logic of the troubleshooting procedures, using wiring diagrams and often consulting vendors of tank components. Because of the relative simplicity of the template, the SME followed models created by the IDs to write content for Troubleshooting Introductions. Consequently, based on the average number of pages in this type of lesson segment, the SME spent proportionately more time on the Troubleshooting Introductions than on the NLFs and IPOs.

Troubleshooting Simulation Lessons. Instructional Designers generated content for the Troubleshooting Simulation template by decomposing TM procedures into their component steps. Many ID hours were needed because

each of the 250 to 450 steps of a procedure required generation of up to nine separate information bits, such as graphics requests, feedback responses, help messages, etc.

The large number of items in Troubleshooting Simulations also required considerable effort on the part of CDs, who were responsible for entering all the data, reviewing the lesson, and debugging the code. To review the lesson the CD had to process the code into the student version and then reprocess to inspect the revisions. Each processing took over one hour. Another factor responsible for CD time was modifying the template code for unforeseen requirements, such as timed displays on automated test equipment. Many CD hours were also spent modifying the code to achieve effects that were not explicitly built into MicroTiccit's ADAPT authoring language. ADAPT makes some kinds of lessons very easy to author, such as Rule-Example-Practice lessons. Using ADAPT to create interactions for which it was not designed, however, required that CDs spend many hours modifying code, testing, and debugging until the required interaction performed flawlessly.

Troubleshooting Simulations required more Graphics Specialist hours per segment than any other type of lesson because they needed realistic graphic images to represent the MI stations, components, and test equipment. These simulations were designed to use graphics instead of video images to shorten the machine response time and to eliminate distracting visual information from the screen. Production of hundreds of realistic images for each simulation was a very labor intensive effort.

Methods were developed to increase graphics production efficiency. The GSs created an on-line character library, a set of drawings of parts such as plugs and cables. The GSs were able to retrieve these images and use them repeatedly as basic construction blocks when they needed to create a new image. They also created an on-line library of complete drawings, such as line replaceable units and test equipment, which could be retrieved and modified for different lessons. These two techniques saved many hours compared to created all drawing anew. Many drawings were created on paper and then transferred to the graphics editor with a digitizing video camera.

The Troubleshooting Simulation template provided the IDs with considerable structure. The IDs generated Troubleshooting Simulation content largely by following the procedures detailed in the TMs. This task of decomposing procedures into their component steps is conceptually easy, but the task was time consuming because of the large number of steps or data items involved. The number of steps in Troubleshooting Simulations typically ranged between 200 and 450 steps. Each individual step required the generation of approximately nine separate bits of information, including graphic requests, at least two different help messages, feedback responses, error messages, etc.

The large number of data items also required a considerable effort on the part of the CDs. In addition to entering the data, the CDs were responsible for debugging the code as well. Debugging requires the

processing of the segment code. This procedure can take up to one hour. The CD then checked the reprocessed code to confirm that the code was bug-free; if it was not, the CD had to continue debugging the code and repeat the time consuming process. Another factor responsible for the amount of CD time, was the adjustment of the template. Over the life of the courseware production phase, CDs found it necessary, depending on the content, to modify the template code in order to achieve special effects. For example, the original template did not include a timed display. When it became necessary to include a timed display in order to simulate a readout of a test set, a senior CD had to modify the code template. More significantly,

Graphics Specialists had to create a substantial number of graphics to represent all of the MI stations, components, and test equipment used for the Troubleshooting Simulations. Troubleshooting Simulations contained no video images; all the images were graphics. Therefore they required more GS hours per segment than any of the other segment types. Troubleshooting Simulation lessons required realistic images of high visual fidelity. The simpler line drawings used in the NLF and IPO lessons were inappropriate for this type of instruction. Production of realistic graphic images was labor intensive. The GSs devised methods for increasing the efficiency of creating images and thereby reduced the number of hours that might otherwise have been required. GSs, instead of creating images on-line, were able to produce many kinds of images faster by rendering them on paper first then using an image digitizing camera to convert the image into data that could be stored in the computer. The GSs created a character library, a set of related parts, such as cables and plug-ends that compose a system or part. By storing these images in the computer, the GSs were able to retrieve them and use them repeatedly as basic construction blocks when they needed to create a new image. The new image did not have to be created from a blank page, instead the items in the character family were used as needed to construct the new image. In a similar fashion, the GSs created a visual library of elaborate drawings that were used repeatedly in MTP-RC courseware. Images of complex line replaceable units and test equipment, such as the multimeter, and breakout box were stored in computer memory and recalled and modified as required. Modifying these detailed images was less time consuming than the time that would have been required to create new images each time.

The SME helped generate the conceptual help messages and checked the large number of items for technical accuracy. This technical review was done once during the initial review and a second time during the final review. The SME also was responsible for locating appropriate graphics from reference material and if the graphic was unobtainable, the SME was responsible for sketching one to aid the GS in producing a finished version of the graphic.

Maintenance Simulation Lessons. Maintenance Simulation lessons were composed of fewer items than Troubleshooting Simulation lessons, but Maintenance Simulation lessons were composed mainly of video images. The large amount of video required more ID time than had been required to

produce the average Troubleshooting Simulation segment. The ID had to spend considerable time locating the best frames to use. Sometimes this occurred because the ID had to choose from a number of possible frames. At other times, the ID was faced with the challenge of finding a frame intended for another screen that could be used to illustrate a step for which specific video was not available. This process was time consuming and required technical guidance from the SME.

In addition to the time required to select the necessary video frames, ID time was spent making instructional decisions at the segment level. The IDs had to make many decisions about what material to include in the lessons and what material was of less importance and could be deleted. The Troubleshooting Simulations were basically a re-creation of every step in the procedure of the Skill Performance Aids (SPAs) manuals. The Maintenance Simulations, on the other hand, deleted many steps that were common mechanic's skills, such as removing bolts. The ID and SME had to make decisions about the inclusion of steps and this required intensive review of the procedure in light of expected entry level skills. Because the template provided multiple ways for the soldier to input a response, the IDs spent time deciding when it was more appropriate to use one response mode than another. For example, the ID could offer the soldier two ways to initiate the simulation of an action, such as the removal of a shaft. The soldier could request the action by marking the image on the screen or by marking a line of text that best describes the desired action. The IDs had to decide which interaction was appropriate depending upon whether the part was clearly visible in the video image.

Fewer hours of CD time were required to produce Maintenance Simulation lessons than Troubleshooting Simulation lessons, because there were fewer items to input into the CBT system. Another reason why less CD time was required was the template itself. When the template was coded, the design of the code was so complete that very few modifications of the code were required. This was true because this was the last template to be designed and it was possible to anticipate variations and exceptions from a standard lesson. In addition, the Maintenance Simulation template avoided the coding problems in the Troubleshooting Simulation template. When production started on Maintenance Simulation lessons, the production team had achieved their greatest familiarity with the content and the authoring system. Fewer CD hours were required to produce Maintenance Simulation lessons than Troubleshooting Simulation lessons because fewer data items required entry, the template facilitated coding, and the CDs were more familiar with the content and with the authoring system.

The primary images used in Maintenance Simulation lessons were video, but GSs spent time enhancing those video images with overlays. The GSs created a library of overlay shapes. Accurately positioning the graphic overlay on the screen required the GS to find the specified video frame and then verify that the overlay was in its proper place. Not as many graphic images had to be produced for Maintenance Simulation lessons compared to the number required for Troubleshooting Simulation lessons, but the images that were required could not be obtained from other lessons, as had sometimes

been the case with other lessons. The graphics and diagrams required for Maintenance Simulation lessons had to be original creations. Producing these original images and producing the overlay shapes took as much time, on average, as the time the GSs needed to produce graphics for the NLF and IPO lessons.

The SME's role in producing the Maintenance Simulation lessons was quite similar to the role he played in the production of the Troubleshooting Simulation lessons. But, because these lessons use many still frame video images, the SME spent many additional hours assisting the IDs in selecting video images that were appropriate and technically correct. The SME also spent time in the initial and final reviews checking the technical accuracy of each instructional screen and help messages available to the soldier on each screen. The SME played an important role in determining which steps were critical to include in these lessons.

Content and Complexity of Instruction. Production costs of lessons are influenced by the complexity of the content contained within the lesson, the amount of content included in the lesson, and the instructional strategies employed to teach that content. It is not possible, with the current data, to quantify the impact of these factors, however their influence on the production of MTP-RC courseware can be discussed. Further research is planned for Phase III of MTP-RC to develop a cost gauge for courseware development.

Designing instruction for NLF lessons was less labor intensive than designing lessons for Troubleshooting Simulations, because the content for NLF lessons required less complex interactions. For example, the content of an NLF lesson might teach the soldier the names of the external parts of an engine transmission while a Troubleshooting Simulation might teach the soldier the exact series of procedures required to diagnose a fault in an electronic component. Generally, content designed to teach tasks composed of many steps and choices required more resources than content designed to teach simpler tasks. Therefore, the complexity of the content and quantity of content influenced production costs. As the complexity of the content increased, the amount of time IDs needed to understand the content increased. Complex technical content affected the amount of SME time required. The SME must consult with the IDs, help identify key points, verify content accuracy, locate reference materials, locate visuals, consult with the GSs to verify the technical accuracy of the graphics, etc. Because MTP-RC courseware presents content about troubleshooting and maintaining sophisticated electronic and mechanical systems, the production of the courseware required extensive resources and labor.

The amount of content included in a lesson also affects the number of labor hours required to produce the lesson. The more content included in a lesson the more resources are required to produce that lesson. In NLF lesson content was based on a tank systems or subsystems. Therefore, a lesson about a system composed of many parts had to cover more content than lessons composed of fewer parts. Additional content affects all four labor categories. For example, IDs had to write more lesson specifications, SME's

had to review more content, CD's had to code and debug more data, and GS's had to create more graphics.

A third factor that affects production costs is the instructional strategy selected to teach the content, because the strategy determines the type of interactions that will be required. Content that requires drill and practice as an instructional strategy can be taught with courseware using a simpler interaction than content which requires simulation. MTP-RC was explicitly intended to demonstrate and evaluate state of the art CBT capabilities, such as complex branching, interactions with videodisc, multicolored graphics, graphic overlays on video images, etc. For example, in a Troubleshooting Simulation lesson a soldier may mark a part on the screen, he may mark one of several action icons to simulate the performance of a task, he may select to receive help, he may move ahead, go back, and exit the lesson. The number of possible interactions per screen is large. A template design with all of these possible interactions requires complex program coding. In addition, all the possible branches, help messages, error messages, graphics, video, and menus had to be specified and created. The selection of simulation techniques to teach some MTP-RC content was labor intensive.

The Authoring Language. Authoring language is another factor which influenced the amount of labor required to produce courseware. Hillelsohn (1984) showed that the authoring language used to produce courseware influences the amount of time required to develop a lesson and that some authoring tools are better and quicker than others at producing particular types of displays. The authoring language used to produce MTP-RC courseware was Hazeltine's ADAPT language. Because ADAPT was the only authoring language used, it is not possible within this report to quantify how it affected CD and GS productivity and production costs. Research is planned within Phase III of MTP-RC that would quantify the effect that authoring languages have on production costs. It is clear that ADAPT defined what interactions are possible, and defined how difficult they were to produce. The graphics editor in the authoring language also determined the ease of producing graphic images. As improvements are made in graphics editors, coding will become more efficient and the associated costs could be expected to decline.

Utilization of the Findings

The number of hours required by each of four labor categories to produce each of five templates was influenced by several factors. The numbers were primarily influenced by the courseware development process, the type and complexity of instruction, and to a lesser extent the authoring system.

Gauging courseware development costs is directly influenced by the courseware development process. The courseware production costs reported in the findings reflect the labor performed by IDs, CDs, SMEs, and GSs during the courseware production process. The steps included in the MTP-RC

courseware development process were listed and each step in the process was described briefly. The reported costs do not include the labor required by personnel during the content analysis, task analysis, training task analysis, and some video production phases. Therefore, if these costs are used to estimate the partial cost of future production projects, care should be exercised to insure that the production process is defined the same way and that cost of additional steps not included in these figures are added to the estimates. The applicability of the data reflects the experience of the production personnel. The number of labor hours required to produce Troubleshooting Introductions, Troubleshooting Simulation lessons, and Maintenance Simulation lessons are based on the fact that when these were produced, the personnel were working at their highest productivity rate. The personnel were familiar and experienced with the ADAPT language, the MicroTICCIT system and the coding templates themselves.

The complexity of the five templates varied and this affected the number of hours that were required to produce lessons. The courseware production costs are also a reflection of the technical nature of courseware content, the amount of content, and the authoring language used to code the courseware. These cost figures could provide a basis for gauging the cost of producing courseware that is of similar complexity and that teaches similar troubleshooting and maintenance skills. If the material has greater technical complexity, then it is likely that more time would be required of all four labor categories. The technical difficulty of the content influences the amount of time necessary for the ID to understand the material. Complex content requires more time for the ID to read the reference materials and more time to consult with SMEs. If the technical material is of greater complexity, then more CD time would be required to enter the data items. More data items require more time to review and debug the material. The degree of complexity also would determine the number and kinds of visual images required. More video would require more ID time, while more graphics would require more GS time. The authoring language affects the hours required for entering program code, debugging, processing code, entering and editing graphics. The use of an authoring language other than ADAPT would alter the number of hours required to code a lesson or create a graphic. For example, some authoring languages might facilitate graphics production but be unable to produce the kinds of interactions that ADAPT can, while others might facilitate revisions. Each authoring language has its strengths and weaknesses and it is difficult to quantify how the authoring language affects production costs without further study.

Summary

The second part of the report contains descriptions of the five lesson templates that compose most of the MTP-RC lessons and descriptions of the responsibilities of the Instructional Designers, Courseware Developers, Subject Matter Expert, and Graphics Specialists who produced the lessons. The steps included in the courseware production process were listed and described. The cost, in terms of labor per labor category, showed how many hours were required to produce lessons based on each of the five templates.

Troubleshooting Simulations were the most labor intensive lessons, closely followed by Maintenance Simulations. Name, Locate, Function and Input, Process, Output lessons were intermediate in labor cost, while Troubleshooting Introductions required the least amount of labor. Each lesson template was analyzed to determine why the number of hours of labor varied from template to template. The results of this analysis were discussed. Finally, the information extracted from the analysis was generalized. The number of hours required by each labor category varied from lesson template to lesson template depending upon the complexity of the content, the amount of content required by the lesson, and the instructional strategy that determined the interactions the template required. Complex content, lengthy content, the high degree of interactivity required to teach the content, and the use of state of the art delivery techniques, all tended to increase the amount of labor to produce a lesson.

Additional courseware can be produced within the same range of hours as reported in Table 6 provided that:

1. Similarly experienced production personnel are used.
2. The courseware treats content of similar complexity and length.
3. Courseware is produced using the same or similar authoring language, lesson templates, and delivery system.

The cost analysis of the MicroTICCIT delivery system for MTP-RC was the focus of the first part of this report. Different systems and configurations of Hazeltine's MicroTICCIT computer systems were analyzed with reference to total system hardware costs and system cost per student-hour. The second part of the report analyzed courseware production costs. The report explained the number of labor hours required to develop five types of lessons. The report examined the influence of critical variables in development time: the steps included in the development process, the complexity and quantity of the content, and the level of interaction required to support the instructional strategy.

The hardware delivery systems cost analysis provides guidance for planners considering the selection and fielding of MicroTICCIT computer-based delivery systems at other reserve training sites. Courseware development cost analysis provides planners with guidance for predicting the cost of developing additional courseware of a similar nature to that developed for MTP-RC. Further research to study and quantify the factors which influence CBT courseware production is planned for Phase III of the Model Training Program for Reserve Component Units.

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APPENDIX A
HAZELTINE MICROTICIT SYSTEMS AND CATALOG PRICES

CATALOG PRICES*

Desktop with 71 megabytes storage	45,000	4,100
Desktop with 142 megabytes storage	60,000	5,300
System II with 50 megabytes storage	55,000	6,000
System II with 100 megabytes storage	71,000	8,000
System III with 147 megabytes storage	95,000	9,500
System III with 294 megabytes storage	125,000	12,000

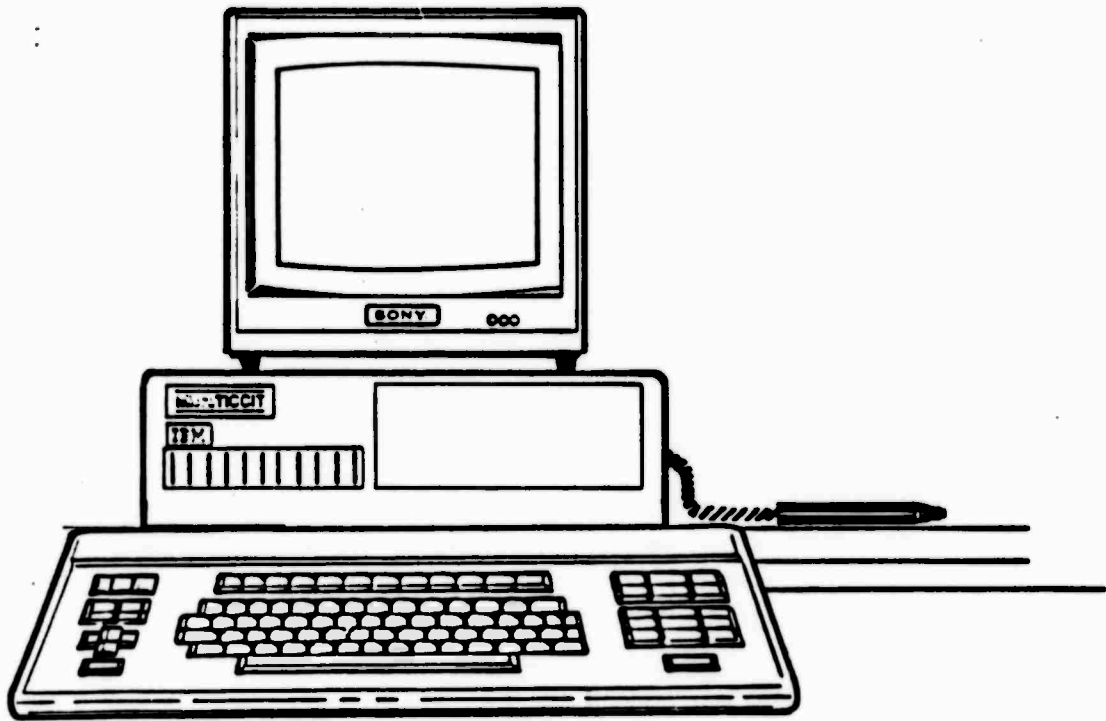
<u>WORKSTATIONS+</u>	<u>ACQUISITION COST</u>	<u>ANNUAL WARRANTY</u>
3 workstations	30,000	3,000
5 workstations	50,000	5,000
10 workstations	100,000	10,000

* These prices were quoted as of December 1985.
Most prices were rounded to nearest \$1,000 by Hazeltine.

+ Workstation prices include videodisc players, network controller, hubs and nodes.

MicroTICCIT[®]

WORKSTATION



Workstation Characteristics:

The MicroTICCIT workstation is a multipurpose station designed for use by students, instructors, courseware developers and training administrators on all MicroTICCIT system configurations. It consists of an IBM Personal Computer, a Sony color monitor, a detachable keyboard with an integral instructional keypad and special function keys, a lightpen, and a high-speed communications link to the system host processor. The display monitor supports color presentations of computer-generated text and graphics, as well as full-color still-frame and motion sequences from videodisc. Under author control, foreground and background colors can be selected from a palette of 4096 colors for use in the creation of each frame of computer-generated text and graphics. In addition, an option is available to allow computer-generated displays to overlay videodisc frames to form a combined display on any MicroTICCIT workstation. This capability allows unprecedented freedom for courseware authors to take advantage of the special attributes of each medium for training.

Workstation Elements:

- o An IBM Personal Computer (PC) with 256 Kbytes RAM. Standard workstations will be provided without diskette drives in the PC. A specially programmed Read-Only Memory (ROM) chip is included to control the workstation's interface to the Network Controller workstation on each system.
- o A Hazeltine Model 430 display interface controlling a Sony 12" (diagonal) full-color monitor. The picture element (pixel) resolution is 430H x 204V. The screen refreshes at sixty frames per second to provide a stable display suitable for extended viewing without eye fatigue. The display supports presentations of computer-generated text and graphics as well as still-frame and motion video.
- o A detached IBM-style keyboard with an expanded keyset. The keyset includes a standard upper- and lower-case alphanumeric keypad, an instructional keypad for direct access to OBJECTIVE, RULE, EXAMPLE, PRACTICE, and HELP components, an editing and cursor control keypad for access to word processing functions such as INSERT and ERASE, and eleven programmable special function keys which can be used to define up to thirty-three special characters or symbols for unique training applications.
- o A lightpen to support interactions via screen touching
- o A communications interface board to link the workstation to the system host processor. The link is established via an ARCNET Local Area Network (LAN) communication system. ARCNET uses a single coaxial cable to connect clusters of workstations to the central host. Distances up to 2000 feet between clusters can be supported with additional cabling and a maximum distance of four miles can be accommodated with the addition of optional active repeaters.

Options:

- o One or two 360Kbyte diskette drives can be added to the IBM PC.
- o A videodisc overlay option can be added to any MicroTICCIT workstation to allow simultaneous display of computer-generated text and graphics and NTSC video combined on a single display. The videodisc image, which can include either still-frame or motion sequences, can be presented on all or any part of the display screen and can be overlaid by computer-generated text or graphics to single pixel resolution. The option includes a Sony laser videodisc player and an overlay interface board that resides in the workstation PC.
- o A random-access EIS audio system can be interfaced to the MicroTICCIT workstation to provide voice-quality audio messages in coordination with visual presentations. Audio can be used to supplement computer-generated as well as video displays. The audio can be freely intermingled with the training materials as desired by the courseware authors.
- o A graphics authoring support package to increase the productivity of the graphics specialist. This includes a three button mouse and 256 Mbytes of additional RAM.

Workstation Specifications

ELECTRICAL SPECIFICATIONS

A.C. Voltage: 120 Volts
Line Frequency: 60 Hertz
Power Consumption: 420 Watts

ENVIRONMENTAL SPECIFICATIONS

Temperature Range: 65° to 75°F (90° max.)
Humidity Range: 40 to 80% (Non-condensing)
Operating Altitude: Up to 8000 Feet

PHYSICAL SPECIFICATIONS

Dimensions: 18"H x 21"W x 27"D
Weight: 70 Pounds

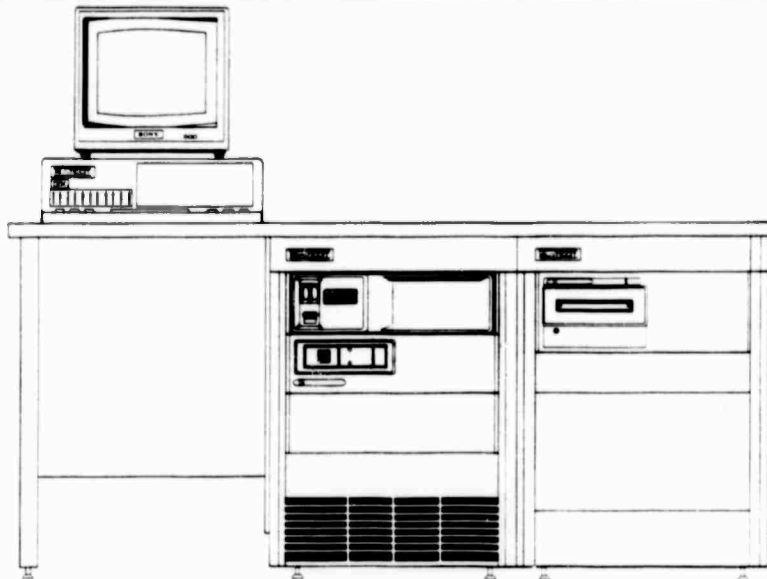


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MicroTICCIT™

System II Configuration



System Characteristics:

The System II configuration is designed to optimize courseware development and delivery for medium-scale computer-based training efforts. The system will support up to forty MicroTICCIT™ workstations, each of which can be used for student, instructor, or author functions. The full MicroTICCIT software package, including all courseware development, graphics, and management software, is supported by System II. In addition, any courseware developed on System II may be used on any other MicroTICCIT system configuration without modification.

System Elements:

- Data General microECLIPSE™ S/20 host processor with 256 Kbytes RAM
- 50 Mbytes of fixed disk storage for on-line system software, student records, and courseware
- 15.4 Mbyte cartridge tape drive for loading or dumping data from fixed disk
- Data General operator console CRT for performing system startup, shutdown, and backup routines
- ARCNET Local Area Network communications interface which allows workstations to be located up to 2000 feet from the host processor and can be extended to four miles with optional active repeaters
- A modem for interfacing to Hazeltine's MicroTICCIT maintenance service network

Options:

- Printing console in lieu of the standard operator console CRT to support hard-copy printing of student management data
- Fixed disk capacity expanded to 100 Mbytes with the addition of another disk unit
- 25 Mbyte streaming tape drive in lieu of the cartridge tape drive

System II Specifications

ELECTRICAL SPECIFICATIONS*

A.C. Voltage: 104 to 127 VAC
Line Frequency: 60 Hertz, \pm 5 Hertz
Power Consumption: 15 Amperes

*Also available for 50 Hz power standards

ENVIRONMENTAL SPECIFICATIONS

Temperature Range: 65° to 75° F (90° max.)
Humidity Range: 40 to 80% (Non-condensing)
Operating Altitude: Up to 8000 Feet

PHYSICAL SPECIFICATIONS

Dimensions: 69"L x 32"W x 30"H (Desk Unit)
Weight: 378 Pounds (172 Kilograms)

HOST PROCESSOR

Type: Data General microECLIPSE S/20
w/Burst Multiplexer
Word Length: 16 bits
Memory Cycle Time: 500 nanoseconds
Memory: 256 KB, byte parity checking standard

DISK STORAGE (STANDARD)

Fixed Disk:
Capacity: 50.7 MB, "Winchester" type
Head Positioning Time: 60 Milliseconds/Average
Rotational Latency: 12.5 Milliseconds/Average
Data Transfer Rate: 971,000 Bytes per second
(Disk to Controller)
881,000 Bytes per second
(Controller to Memory)

TAPE STORAGE

Cartridge Tape:
Capacity: 15.4 MB/450 foot tape
Data Transfer Rate: 48,000 Bytes per second
Speed: 60 Inches per second
Density: 6400 Bits per Inch

LOCAL AREA NETWORK (LAN)

Type: ARCNET
Speed: 2.5 Megabits per second
Cable Length: Maximum 2000 feet
Error Checking: 16 Bit Cyclic Redundancy Check
(CRC) on data and addresses
Error Recovery: Automatic Retransmission
Maximum Terminals per System: 40 Recommended

The materials contained herein are summary in nature, subject to change, and intended for general information only

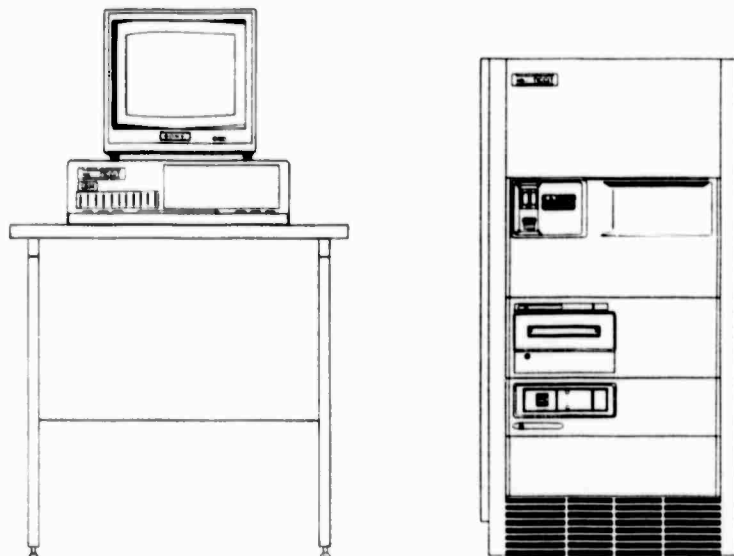


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MicroTICCIT™

System III Configuration



System Characteristics:

The System III configurations provide a family of systems designed to optimize courseware development and delivery for large-scale computer-based training efforts. Each configuration will support up to sixty-four MicroTICCIT™ workstations which can be used for either student, instructor, or author functions. The full MicroTICCIT software package, including all courseware development, graphics, and management software, is supported by the System III configurations. In addition, any courseware developed on a System III configuration may be used on any other MicroTICCIT system configuration without modification.

System III Elements:

- Data General microECLIPSE™ S/120 host with 256 Kbytes RAM
- 15 Mbytes of fixed disk storage for rapid "swapping" of data from disk to processor
- Additional fixed disks for on-line storage of software, student records, and courseware
 - System III-A: 50 Mbytes
 - System III-B: 73 Mbytes
 - System III-C: 147 Mbytes
- Tape drive for loading or dumping data from the fixed disks
 - System III-A: 15.4 Mbyte Cartridge Tape
 - System III-B: 25 Mbyte Streaming Tape
 - System III-C: 25 Mbyte Streaming Tape
- Data General operator console CRT for performing system startup, shutdown, and backup routines
- ARCNET Local Area Network communications interface, which allows workstations to be located up to 2000 feet from the host processor and can be extended to four miles with optional active repeaters
- A modem for interfacing to Hazeltine's MicroTICCIT maintenance service network

Options:

- Printing console in lieu of the standard operator console CRT to support hard-copy printing of student management data
- High-speed dot matrix printer to support hard-copy printouts of software and courseware files
- Graphics digitizer to facilitate the entry of large numbers of graphics into the courseware database
- Device control interfaces to support control of custom devices, including random-access audio cassettes and 3-D panels

System III Specifications

ELECTRICAL SPECIFICATIONS*

A.C. Voltage: 104 to 127 VAC
Line Frequency: 60 Hertz, \pm 5 Hertz
Power Consumption: 25 Amperes

*Also available for 50 Hz power standards

ENVIRONMENTAL SPECIFICATIONS

Temperature Range: 65° to 75° F (90° max.)
Humidity Range: 40 to 80% (Non-condensing)
Operating Altitude: Up to 8000 Feet

PHYSICAL SPECIFICATIONS

Dimensions: 51"H x 24"W x 30"D (Rack)
Weight: 460 Pounds (209 Kilograms)

HOST PROCESSOR

Type: Data General microECLIPSE S/120
Word Length: 16 bits
Memory Cycle Time: 500 nanoseconds
Memory: 256 KB, ERCC (22 Bit)

LOCAL AREA NETWORK (LAN)

Type: ARCNET
Speed: 2.5 Mbits Per Second
Cable Length: Maximum 2000 Feet
Error Checking: 16 Bit Cyclic Redundancy Check (CRC) on Data and Addresses
Error Recovery: Automatic Retransmission
Maximum Terminals per System: 64 Recommended

DISK STORAGE (STANDARD)

Swapping Disk:
Capacity: 15MB, "Winchester" Type
Head Positioning Time: 66 Milliseconds/Average
Rotational Latency: 9.5 Milliseconds/Average
Average Access Time: 75.5 Milliseconds
Data Transfer Rate: 266,000 Bytes Per Second (Controller to Memory)

Fixed Disk:
System III-A:
Capacity: 50.7 MB, "Winchester" type
Head Positioning Time: 60 Milliseconds/Average
Rotational Latency: 12.5 Milliseconds/Average
Data Transfer Rate: 242,000 Bytes per second (Controller to Memory)

System III-B/System III-C:
Capacity: 73.7/147.4 MB, "Winchester" Type
Head Positioning Time: 30 Milliseconds/Average
Rotational Latency: 8.33 Milliseconds/Average
Data Transfer Rate: 600,000 Bytes per second (Controller to Memory)

TAPE STORAGE

System III-A:
Capacity: 15.4 MB, Cartridge Tape
Data Transfer Rate: 48,000 Bytes per second
Speed: 60 Inches per second
Density: 6400 Bits per inch

System III-B and System III-C:
Capacity: 26.7 MB, Streaming Tape
Data Transfer Rate: 48,000 Bytes per second
Speed: 30 Inches per second
Density: 1600 Bits per inch

The materials contained herein are summary in nature, subject to change, and intended for general information only

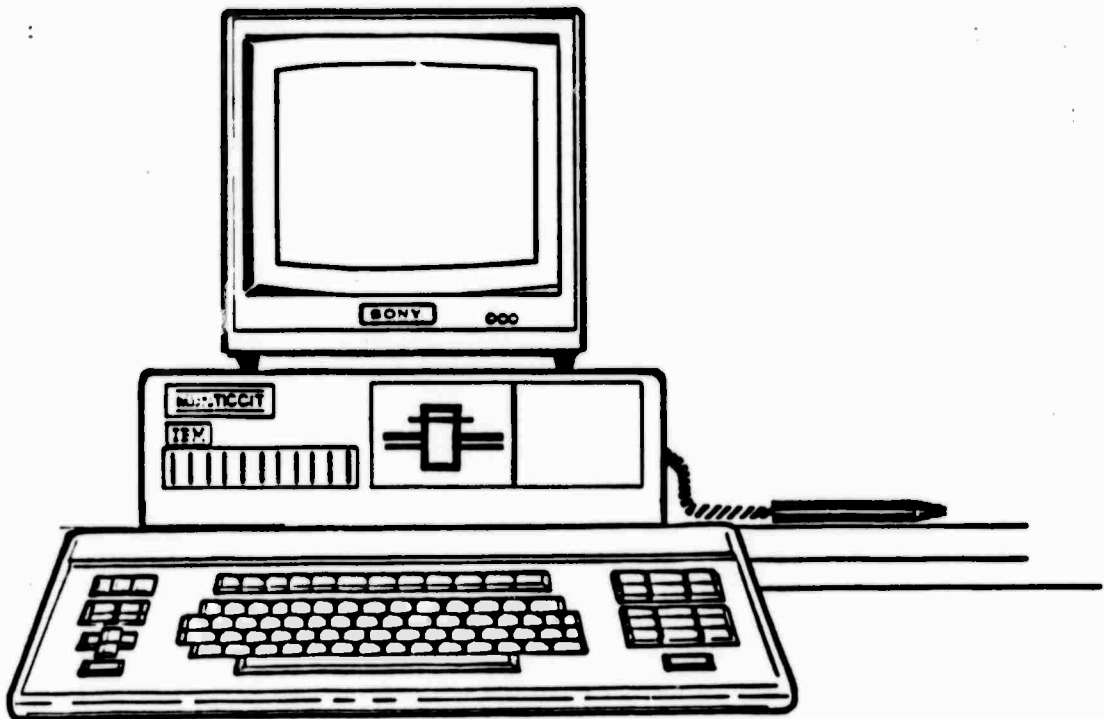


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MicroTICCIT[®]

NETWORK CONTROLLER WORKSTATION



Network Controller Workstation Characteristics:

The MicroTICCIT network controller workstation controls all interactions between the MicroTICCIT host processor and the standard MicroTICCIT workstations on each system. A high-speed Direct Memory Access (DMA) interface is used to establish the link between the host processor and the network controller workstation. Although the network controller workstation supports the full set of student, instructor, courseware development and training administration functions provided by all standard MicroTICCIT workstations, the DMA link makes it necessary for the network controller workstation to be located within ten (10) feet of the MicroTICCIT host processor.

The network controller workstation consists of an IBM Personal Computer with one (1) 360K byte diskette drive, a Sony color monitor, a detached keyboard with an integral instructional keypad and special function keys, a lightpen, and a communications link to all of the standard workstations on the system. The display monitor supports color presentations of computer-generated text and graphics, as well as full-color still-frame and motion sequences from videodisc. In addition, an option is available to allow computer-generated displays to overlay videodisc frames to form a combined display.

Workstation Elements:

- o An IBM Personal Computer (PC) with 256 Kbytes RAM and one (1) 360 Kbyte diskette drive.
- o A Hazeltine-Model 430 display interface controlling a Sony 12" (diagonal) full-color monitor. The picture element (pixel) resolution is 430H x 204V. The screen refreshes at sixty frames per second to provide a stable display suitable for extended viewing without eye fatigue. The display supports presentations of computer-generated text and graphics as well as still-frame and motion video.
- o A detached IBM-style keyboard with an expanded keyset. The keyset includes a standard upper- and lower-case alphanumeric keypad, an instructional keypad for direct access to OBJECTIVE, RULE, EXAMPLE, PRACTICE, and HELP components, an editing and cursor control keypad for access to word processing functions such as INSERT and ERASE, and eleven programmable special function keys which can be used to define up to thirty-three special characters or symbols for unique training applications.
- o A lightpen to support interactions via screen touching
- o A high-speed communications interface board to link the network controller workstation to the system host processor.
- o A network communications interface board to link the network controller workstation to the rest of the workstations on the system network. The link is established via an ARCNET Local Area Network (LAN) communication system.

Options:

- o An additional 360 Kbyte diskette drive can be added to the IBM PC.
- o A videodisc overlay option can be added to allow simultaneous display of computer-generated text and graphics and NTSC video combined on a single display. The videodisc image, which can include either still-frame or motion sequences, can be presented on all or any part of the display screen and can be overlaid by computer-generated text or graphics to single pixel resolution. The option includes a Sony laser videodisc player and an overlay interface board that resides in the workstation PC.
- o A random-access EIS audio system can be interfaced to the controller workstation to provide voice-quality audio messages in coordination with visual presentations. Audio can be used to supplement computer-generated as well as video displays. The audio can be freely intermingled with the training materials as desired by the courseware authors.
- o An AXIOM screen-image printer can be added to the workstation to provide black-and-white hard-copy printouts of any computer-generated text or graphic display.

Workstation Specifications

ELECTRICAL SPECIFICATIONS

A.C. Voltage: 120 Volts
Line Frequency: 60 Hertz
Power Consumption: 420 Watts

ENVIRONMENTAL SPECIFICATIONS

Temperature Range: 65° to 75°F (90° max.)
Humidity Range: 40 to 80% (Non-condensing)
Operating Altitude: Up to 8000 Feet

PHYSICAL SPECIFICATIONS

Dimensions: 19"W x 21"W x 27"D
Weight: 70 Pounds



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MicroTICCIT[®]

VIDEO OVERLAY OPTION

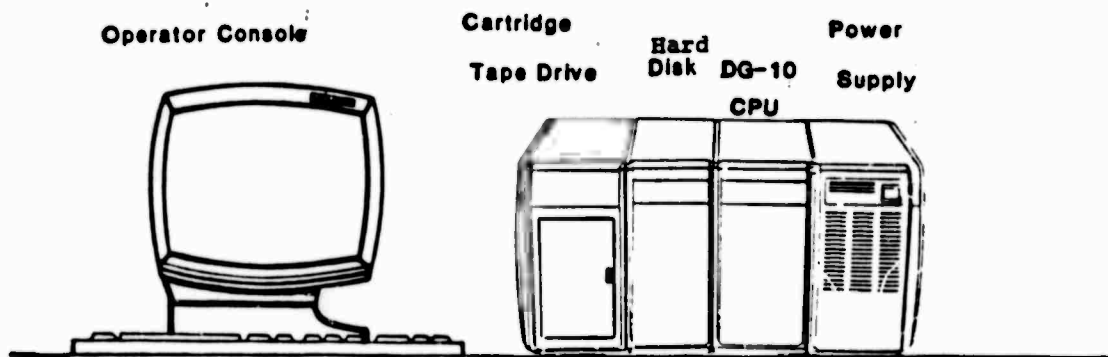
The videodisc overlay option allows simultaneous display of computer-generated text, graphics, and NTSC video from videodisc combined on a single MicroTICCIT workstation display. The video, which can include either still-frame or motion sequences, can be presented on all or any part of the display screen and can be overlaid by computer-generated text or graphics to single picture element (pixel) resolution.

The videodisc overlay option includes a Sony laser videodisc player, a specially-designed video overlay interface board that resides in the workstation IBM PC, and all necessary cables.

Each videodisc option is dedicated to a single terminal and cannot be shared. The option may be ordered for one, a few, or all MicroTICCIT workstations on any MicroTICCIT system.

MicroTICCIT[®]

SERIES 10



System Characteristics:

The MicroTICCIT Series 10 provides a cost-effective configuration for delivering courseware developed on larger MicroTICCIT systems for small-scale training applications. The system will support up to ten MicroTICCIT workstations, each of which can be used for student, instructor, and training management functions. The Series 10 System is ideally suited for those applications that require courseware developed at a central authoring facility to be delivered to one or more satellite facilities. All software required to support the efficient delivery of courseware and the collection of student progress data is provided with the system. The Series 10 system is not designed to support courseware development functions.

The MicroTICCIT Series 10 is available in two standard configurations differing only in the amount of disk storage provided:

- Model 38 provides 38 Mbyte of storage
- Model 71 provides 71 Mbyte of storage

System Elements:

- o Data General DG-10 desktop processor with 768 Kbytes RAM
- o 38 Mbyte fixed disk (Model 38) or 71 Mbyte fixed disk (Model 71) for on-line storage of system software, student records, and courseware

- o 15.4 Mbyte cartridge tape drive for loading or dumping data from the fixed disk
- o 368 Kbyte floppy diskette drive for running system diagnostics
- o Data General operator console CRT for performing system startup, shutdown, and backup routines
- o ARCNET Local Area Network (LAN) communications interface to link MicroTICCIT workstations to the Desktop System host processor
- o A modem for interfacing to Hazeltine's MicroTICCIT maintenance service network

Options:

- o Printing console in lieu of the standard operator console CRT to support off-line printing of student management data
 - o Add-on 38 Mbyte fixed disk (Model 38) or 71 Mbyte fixed disk (Model 71) to double the system's on-line storage capacity
-



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APPENDIX B
FORMULAS FOR COMPUTING SYSTEM COST PER STUDENT-HOUR

SYSTEM ACQUISITION PRICE = [(HOST ACQUISITION PRICE + (WORKSTATION ACQUISITION PRICE * NUMBER WORKSTATIONS)]

TOTAL SYSTEM COST = [((HOST ACQUISITION PRICE * (CPU ANNUAL MAINTENANCE RATE * YEARS)) + ((COST OF WORKSTATIONS + (ANNUAL WORKSTATION MAINTENANCE RATE * WORKSTATIONS * YEARS)))]

SYSTEM COST PER WORKSTATION = TOTAL SYSTEM COST / NUMBER OF WORKSTATIONS

ANNUAL SYSTEM COST PER WORKSTATION = SYSTEM COST PER WORKSTATION / NUMBER OF YEARS

TOTAL WORKSTATION HOURS PER YEAR = (NUMBER OF SOLDIERS * NUMBER OF DRILL PERIODS PER YEAR * HOURS PER DRILL PERIOD)

ANNUAL WORKSTATION UTILIZATION RATE = TOTAL WORKSTATION HOURS PER YEAR / NUMBER OF WORKSTATIONS

SYSTEM COST PER STUDENT HOUR = ANNUAL SYSTEM COST PER WORKSTATION / ANNUAL WORKSTATION UTILIZATION RATE

APPENDIX C

STRUCTURE OF MTP-RC COURSEWARE

The MTP-RC courseware is structured in such a way as to be compatible with the MicroTICCIT Computer-Based Management System. Each course -- one for each MOS -- is divided into 3 instructional categories:

1. Units - One for each tank system covered in the course.
2. Lessons - Two for each Unit within a course.
3. Segments - One for each instructional objective being taught within a lesson.

Figure A-1 shows the flow of instruction within an MOS course. There is, in addition, one course which provides M1 skills sustainment training. The content of this course and a general description of the instructional structure of the MOS courses follows.

The M1 Skills Sustainment Training Course is divided into two units. Unit One serves as an introduction to the M1 tank, the MicroTICCIT CBT system, and the structure and content of the MTP-RC courseware. Unit One also includes instruction on how to use the MicroTICCIT student workstation to complete the courseware.

Unit Two is designed to provide RC soldiers with the skills and knowledge that are prerequisite to successfully complete the MTP-RC courseware. For those who have completed Level 1 training, this unit can be considered as sustainment training. For those who have not acquired the necessary skills, Unit Two will serve as prerequisite skills training. Topics covered in this unit include use of technical manuals, use of the STE-M1, DSESTS, and Digital Multimeter.

As Figure C-1 shows, Units comprise the tank systems covered in a course. In each unit there are two lessons: Principles of Operations and Troubleshooting/Maintenance. Each lesson has one to three segments. Instructional interactions are defined at the segment level. The design of each of these segments was based on one of five templates.

Principle of Operations segments are based on either the NLF and IPO templates. The lessons are designed to provide student with an understanding of the purpose and function of a tank system, its component parts, and its general operation. Such information should assist the student in troubleshooting selected system symptoms. This lesson has one or two types of segments, depending on the complexity of the system: Name, Location, Function (NLF) and Input, Process, Output (IPO).

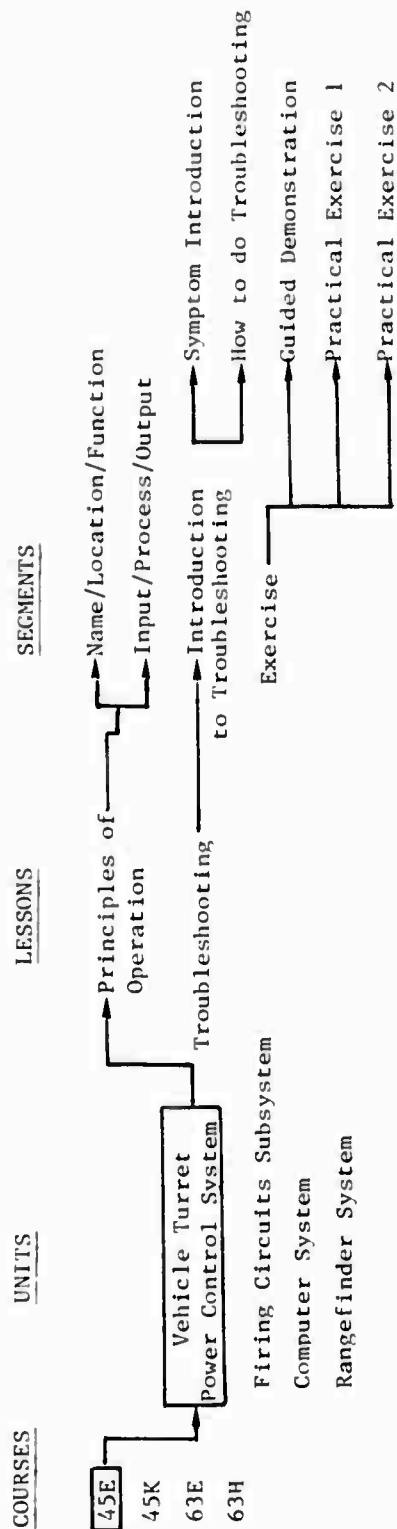


Figure C-1. Flow of instruction.

Name, Locate Function Template

The NLF template defines the interactions contained within NLF segments. The primary purpose of a Name, Location, Function segment is to teach the name, functional location and function of each of the important components of a single tank system. The student learns the function of the entire system, how the components work together in the system, and what happens if the system is not working correctly. In this segment, the student is presented with a functional block diagram of the entire system. This diagram shows the functional relationship among the components in the system, so the student learns the functional position of the component in relation to the others. In a few systems, such as the engine, the student also learns the actual physical location. After selecting on individual component, the students see a video or graphic image of the component and a brief description of its function. An system the components are stuio in this manner. The student then demonstrates he has learned by completing a practice exercise in which he identifies the name, location and function of each component. At the end of the segment, the student reviews what he has learned.

The Input, Process, Output Template

The Input, Process, Output (IPO) template structures the set of possible interactions within IPO segments. AN IPO segment is designed to accomplish two specific goals. First, information about each system part is presented in greater depth than in the NLF segment. In the IPO segment, soldiers learn:

1. Those elements (electricity, data, fuel) that come into a part and the sources and those elements.
2. What happens to those elements while in the part.
3. What elements (electricity, data) are output by the part and the destination of those elements.

For example, a computer might receive data from three electronic sensors. These data comprise the INPUT. Then, the computer performs a clearly defined set of mathematical operations on those data. The results are then evaluated. This represents the PROCESS. The computer sends signals to three other tank parts. The signals represent the OUTPUT. By studying the NLF and IPO for any part, the soldier learns both what a part does functionally, and how this function is accomplished.

A second, and no less important, goal of the IPO segment is to reinforce the concept of the tank as an integrated system. While the NLF segment focuses on one system or subsystem, the IPO segment shows the relationship among several systems. The reason, of course, is that input and output is not limited to a specific system; it is the input and output

of parts, subsystems, and systems that shows the integration of all tank systems.

The second lesson in each unit is Troubleshooting/Maintenance, which uses part-task simulations of troubleshooting or maintenance tasks. Troubleshooting lessons are defined by the Troubleshooting Simulation template and Maintenance lessons are defined by the Maintenance Simulation template. There are two segments within each Troubleshooting/Maintenance lesson: Introduction to Troubleshooting and Troubleshooting/Maintenance Exercises. For the 45E, 63E and 45K, the simulations are mainly electronic troubleshooting and for the 63H, mainly mechanical maintenance procedures. This content reflects the principal skill level 2 critical tasks for the respective MOSs.

Troubleshooting Introductions Template

The first segment, Introduction to Troubleshooting, provides a transition between the Principles of Operation segments and the simulations the student will perform. The Troubleshooting Introduction template is composed of two sections: Symptom Introduction and How to do Troubleshooting.

In the Symptom Introduction, the system diagram presented in the Principles of Operation lesson serves as the foundation on which troubleshooting knowledge is built. All of the components which could not be responsible for the symptom are deleted from the diagram, and components outside the system which could cause the symptom are added. This provides the student with the "feasible set" of all possible causes of the fault. The student then learns how each component could cause the fault and what tests will be performed in order to isolate the fault. The Symptom Introduction also includes a review of the rules that must be applied while completing troubleshooting simulations.

The troubleshooting approach presented in the introduction models the cognitive processes of experienced troubleshooters and can help students develop the ability to locate system components that could a fault. The approach may lead some soldiers to develop skills and knowledge necessary for becoming superior technicians. For other students, the introduction will provide understanding off why specific tasks are being performed and will illustrate the relationship between symptoms that occur within the same system.

The second section of this segment, called "How to do Troubleshooting", is the same in every lesson. Its purpose is to teach the student how to use the troubleshooting simulation it is always available for students in need of review. This section consists of a short section which explains how Guided Demonstrations and Practical Exercises work, and two sections which explain how the student will interact with the Technical Manuals (TMs) and the computer.

Troubleshooting and Maintenance Simulation Templates

The Troubleshooting Simulation and Maintenance Simulation templates define the set of possible interactions within the troubleshooting and maintenance exercise segments. These segments generally consist of three sections: Guided Demonstration, Practical Exercise 1 and Practical Exercise 2. All exercises are based on the M1 TMs. The student is required to use the appropriate TM as a constant job aid when performing troubleshooting actions. MicroTICCIT provides the tank and test equipment, as well as help, prompts, and explanations. Maintenance Simulation lessons are primarily intended for 63Hs who are responsible for repairing the engine and the transmission. The actual performance of troubleshooting these systems is heavily dependent on the soldier's visual inspection of the equipment. Because actual equipment is unavailable for training, the maintenance lessons are designed to allow the soldier to visually inspect video images of the systems to identify the fault responsible for the symptom. In addition to familiarizing the soldiers with the equipment and how to manipulate it, maintenance lessons teach the soldier specific procedures for removing, repairing, and installing engine and transmission components.

The Guided Demonstrations (GDs) and Practical Exercises (PEs) cover the same symptom but follow different paths through the troubleshooting procedure and lead to different faults. This approach enables the student to repeat some steps within a procedure as well as performing new steps. The goal of the troubleshooting exercises is for the student to simulate troubleshooting the fault symptom using the TM as a job aid. The student is not expected to memorize the steps required to troubleshoot a particular symptom, but rather is expected to understand the use of the TMs for troubleshooting symptoms.

The design of the template defines the types of interactions that are permitted within the lesson. The following section describes the main interactions permitted by the templates.

The main part of the screen, called the work area, displays detailed graphics showing the tank, system components, and test equipment. It is in this area that the student locates his workplace, identifies the required components, and performs tests and checks. Continuous guidance is provided on a feedback line. Below this line are both action icons (such as remove, replace, connect) and tool icons (such as the breakout box, cables, adapters and jumper cables). The electronic troubleshooting procedures are presented with computer generated graphics, while the maintenance procedures (63H) primarily use videodisc images.

The student is required to follow the TM word-by-word, completing each step by marking the appropriate component, actions, and tools. After each action, the display changes in whatever way the student has indicated as long as he continues to mark correctly. When the student makes a mistake, he receives immediate corrective feedback and cannot continue until the correct step have been completed. The student continues on the path

through the procedure until he finds the fault. He then orders the replacement of the faulty component and verifies that the problem is solved.

Throughout the Troubleshooting Simulation, two kinds of help available to the student including:

1. What to do next if the student gets lost or does not know what to do.
2. Reminders on how to use the simulation icons if the student forgets.

APPENDIX D
WORK SUMMARY

(transcribed from Courseware Developer's handwritten log)

Name Jeff

Date	Hours	Segment	Comments (e.g. video, data entry, debug, finished)
5/13	3	E4.2.2.3	final error corrections
5/13	5	H6.1.6.1	graphics and code debug
5/15	4	H6.1.6.1	" " " " "
5/14	2.5	E6.5.2.1	final CD review
5/14	1.5	E6.5.2.2	final CD review
5/15	5.5	E6.5.2.2	" " "
5/15	1	---	division meeting
5/15	1.5	E5.2.2.3	error corrections
5/16	1.5	---	meeting-company
5/16	6.5	E6.2.2.3	error corrections
5/17	4	E6.5.2.3	final CD review
5/17	4	E4.2.2.3	error correction
5/20	8	H6.1.7.1	data entry and graphics
5/21	6	H6.1.7.1	" " " "
5/21	2	H6.2.1.4	video integration
5/22	8	H6.2.1.4	video integration and debug
5/23	2.5	E6.5.1.7	final CD review
5/23	2.5	E6.5.2.1	" " "
5/23	3.0	E6.5.1.6	final CD review and learning environment specifications
5/24	1.0	"	" " " " " " "
5/24	4.0	E6.5.2.2	" " " " " " "
5/24	3.0	E6.5.2.3	" " " " " " "
5/28	1	E6.5.2.3	" " " " " " "
			D-1

Joni Jay

Employee

Month MARCH

Year 1985

Total Hours	168
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JOB #	ACRONYM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	TOTAL	API
		F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S		

[illegible]

DIRECT

[illegible][illegible]

CONTRIBUTED

Employee Signature

Don Day

Department Signature: 